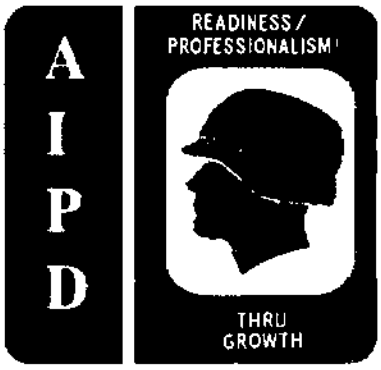
SUBCOURSE
SS0332

EDITION
5

INTRODUCTION TO CIRCUIT CONDITIONING

THE ARMY INSTITUTE FOR PROFESSIONAL DEVELOPMENT

ARMY CORRESPONDENCE COURSE PROGRAM



US ARMY STATION TECHNICAL CONTROL COURSE
MOS 32D SKILL LEVEL 1

INTRODUCTION TO CIRCUIT CONDITIONING

SUBCOURSE NO. SS0332-5

US Army Signal School
Fort Gordon, Georgia

Six Credit Hours

GENERAL

This subcourse, part of MOS 32D, is designed to provide you with a basic knowledge necessary for performing task related to circuit conditioning testing of voice frequency (VF) circuits by; determining the quality of VF circuits, categories of VF circuits; identifying the types of tests performed; types of test equipment; and the characteristics of the test equipment used during circuit conditioning. Subcourse SS 0330, Introduction to Telephone and Telegraph Transmission MUST BE taken prior to taking this subcourse.

Lesson 1: COMMUNICATION CIRCUIT QUALITY.

TASK: Describe the characteristics that affect signal quality, causes and effects of signal quality, and principles of measuring signal distortion of VF circuits IAW Defense Communications Agency (DCA) standards.

CONDITIONS: Given information about VF circuit characteristics, signal quality, principles of measuring signal distortion and VF circuit standards established by DCA.

STANDARDS: Demonstrate competency of the task skills and knowledge by responding to the multiple-choice practice exercise; select the ONE answer that BEST completes the statement or answers the question, covering communication circuit quality.

(This objective support tasks, 113-616-3018, Test Circuit for Impulse Noise, TD-8; 113-616-3020, Test Circuit for Composite Data Transmission Level, TD-10; 113-616-3062, Determine Test Tone Level; 113-616-3075, Test Circuit for Basic Noise, TD-6; 113-616-3031, Perform In-Service QC Tests.)

Lesson 2: CONCEPTS OF CIRCUIT CONDITIONING.

TASK: Describe the duties of technical controller, determine circuit parameters using the Defense Communication System (DCS) technical schedule, and if VF circuits meet selected DCS parameters.

CONDITIONS: Given information about the duties of a technical controller, description of DCS technical schedule, and an extract from DCAC 300-175-9 of a DCS Technical Schedule.

STANDARDS: Demonstrate competency of the task skills and knowledge by responding to the multiple-choice practice exercise; select the ONE answer that BEST completes the statement or answers the question, covering concepts of circuit conditioning.

(This objective support tasks 113-616-3018, Test Circuit for Impulse Noise, TD-8; 113-616-3020, Test Circuit for Composite Data Transmission Level, TD-10; 113-616-3062, Determine Test Tone Level; 113-616-3075, Test Circuit for Basic Noise, TD-6; 113-616-3031, Perform In-Service QC Tests.)

Lesson 3: CIRCUIT CONDITIONING TEST SETS.

TASK: Identify the type and use of the test equipment, describe the function of the front panel controls and characteristics of the test and equalizer equipment CONDITIONS: Given information about the type, use, characteristics and function of the front panel controls for the test and equalizer equipment used in circuit conditioning.

STANDARDS: Demonstrate competency of the task skills and knowledge by responding to the multiple-choice practice exercise; select the ONE answer that BEST completes the statement or answers the question, covering circuit conditioning test sets.

(This objective supports Tasks 113-616-3018, Test Circuit for Impulse Noise, TD-8; 113-616-3020, Test Circuit for Composite Data Transmission Level, TD-10; 113-616-3062, Determine Test Tone Level; 113-616-3075, Test Circuit for Basic Noise, TD-6; 113-616-3031, Perform In-Service QC Tests.)

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Whenever pronouns or other references denoting gender appear in this document, they are written to refer to either male or female unless otherwise indicated.

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DESCRIPTION OF THE IMPROVEMENTS MADE IN COMMUNICATION CIRCUITS OVER THE LAST DECADE

1. There was a time in the experience of many communicators when "any old telephone line" would do, so long as they could talk over it. Those days are rapidly disappearing. In this age of high-speed computers and rising speeds of transmission, such a simple approach to communication will not suffice. Not only must the quality of circuits remain high; they must also be conditioned to accept and transmit the various types of complex signals.

2. Over the past decade our engineers have produced and delivered large numbers of highly sophisticated devices for communication between stations. However, the capability of the telephone facilities did not keep pace with equipment developments. The reason is largely economic: telephone facilities already exist. Why provide expensive duplication of existing lines? Let us use the lines we already have.

3. Now the circuit conditioner enters on the stage of communication history. As he plies his new trade he is able to make ordinary quality telephone lines accept and transfer information at a higher rate than he could ever have hoped for in the past.

LESSON 1
COMMUNICATION CIRCUIT QUALITY

TASK: Describe the characteristics that affect signal quality, causes and effects of signal quality, and principles of measuring signal distortion of VF circuits IAW Defense communications Agency (DCA) standards.

CONDITIONS: Given information about VF circuit characteristics, signal quality, principles of measuring signal distortion and VF circuit standards established by DCA.

STANDARDS: Demonstrate competency of the task skills and knowledge by responding to the multiple-choice practice exercise; select the ONE answer that BEST completes the statement or answers the question, covering communication circuit quality.

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REFERENCES: DCAC 310-70-1, Volumes I, II, and III.
DCAC 310-70-1, Volume II, Supplement 1 and 2.
DCAC 300-175-9 MIL-STD-198-101

Learning Event 1: QUALITY OF COMMUNICATION.

Electrical communication is carried by wire or radio, or by a combination of the two. The quality of communication by either wire or radio is affected by noise, interference, and distortion. When none of the three are present, the circuit quality and the signals are said to be perfect. Although no communication circuit has perfect quality, every attempt is made by communicators to reduce the effect of noise, interference, and distortion.

a. Noise. There are two forms of noise: natural and manmade. Natural noise results from atmospheric conditions, while manmade results from electrical appliances and devices.

b. Interference. Interference is the disturbance caused within a signal by extraneous signals. Interference in cables usually results from electromagnetic or electrostatic induction between wire pairs. Interference between radio stations is caused by careless operators or unstable radio transmitters.

c. Distortion. Distortion is the result of variation or change in the amplitude, phase, or frequency of an audio signal, or the change in length of DC signal pulses.

d. Total effect. The total disturbing effect on a signal is the result of the cumulative effect of noise, interference, and distortion. Although these disturbances can be defined and discussed, they are difficult to extract from the signal once they have entered it. Prevention of these disturbances is therefore more important than compensating for their effect.

Learning Event 2: EFFECT OF NOISE.

The effect of noise on a signal is never known until the signal is demodulated. The effect of noise must therefore be observed at the receiving device.

a. General. Noise can occur on specific frequencies, or it can be a type that is spread equally over a wide part of the frequency spectrum. Impulse noise and AC hum usually are frequency selective--that is, they occur only on specific frequencies. Types of noise often present on radio circuits, such as thermal noise, cosmic noise, atmospheric noise, etc., are generally broad and evenly distributed across a wide band. These noise types are classified as "white" noise, to differentiate them from impulse noise.

b. Signal-to-noise ratio. The actual signal strength is not the most important factor in a communication circuit, since a weak signal can always be amplified. However, noise in the circuit is amplified at the same time. Also, additional amounts of noise are added at each amplifier. Therefore, the more times the signal is amplified in an overall system, the higher the noise level. If the noise level at the receiving device is far enough below the signal level so that the receiving mechanism can be adjusted to operate only on the desired signal and to ignore the lower amplitude noise, then the noise has no effect on the signal. The relationship between the amplitude of the signal and amplitude of the noise is called the signal-to-noise-ratio. This ratio is the limiting factor for reliable communication.

Learning Event 3: SUPPRESSION OF MANMADE RADIO NOISE.

a. An electric spark developed across relay contacts or electric motor brush contacts generates RF noise which, unless suppressed, can cause disruption of radio reception. Suppression of radio noise from sparking contacts can frequently be achieved by devices called suppressors, or spark killers. The common type

of spark killer used with DC telegraph and teletypewriter relays or keying contacts consists of a resistor in series with a capacitor, connected across the contacts. The connecting leads must be kept as short as possible. Teletypewriter transmission measurement must be taken before and after installation of spark killers to detect any-possible deterioration of waveshape that may in turn result in garbled or distorted signals (telegraph distortion). The commutators and sliprings of motors and generators require only the capacitor for adequate spark suppression.

b. To suppress noise caused by spark ignition systems, installation of standard suppressors without shielding gives considerable improvement at frequencies below 30 MHz, and some improvement at higher frequencies. Shielding of the device causing the noise may be necessary if suppression does not reduce the noise sufficiently. The criticalness of joints and materials in high-tension ignition shielding is greatly reduced by the use of suppressors. Army tactical vehicles, engine-driven equipment, and electrical and electronic equipment are normally suppressed from 0.15 to 1,000 MHz.

c. Radio noise may be "bottled up" within a well-shielded source by filters across all leads connected to the source. Typical bypass capacitors, even with very short leads, are effective up to only a few MHz, since they become less effective above their self-resonant frequencies. High-quality feed-through suppression capacitors must be used where HF suppression is required, because they are effective up to 1,000 MHz.

d. When installing cables within the receiving station, it is advisable to separate conductors carrying RF signals from all other conductors. It is also advisable to pass voice and DC signals through separate cables to prevent crossfire of DC pulses into the voice signals. Such crossfire sounds like thumps or clicks in the voice signals. This type of noise is classified as "impulse" noise.

e. The ground connection of a radio receiver often carries noise into the receiver. The best remedy is to provide short, direct, independent connections from the receiver and from the noise source to separate low-impedance grounds. Keep all receiver ground leads physically and electrically separated from the ground leads of any noise source.

f. Good bonding maintenance and practices are essential to obtain low-impedance ground connections between equipment or suppressors and vehicles or frames, thereby preventing generation or spread of radio noise. Connections should be direct, and

contacting surfaces clean, bright, and firmly held together. Movable parts should be bonded to the stationary frame with flexible straps of tin-copper braid. Such straps should be kept as short as possible to reduce their inductance.

g. Good electrostatic shielding of a receiver (or any noise-producing equipment) can be insured by enclosing the receiver in a high-conductivity metallic shield, such as solid copper, aluminum shielding, or copper screening. All wires entering or leaving the equipment (except the antenna leads) should be properly bypassed or filtered. Necessary holes or cracks in a shielding should be kept as small as possible. Shielding can be improved by bonding the joints at closely spaced points. The lower the frequency, the thicker must be the shield. Because of the strong electromagnetic field that occurs at low frequencies, a sheet-iron shield may be more effective than one made of copper or aluminum.

Learning Event 4: IMPROVING THE SIGNAL-TO-NOISE RATIO.

Circuit reliability in long-distance radio operation depends to a large degree on the signal-to-noise ratio (S/N). The higher this ratio (high signal strength compared with noise level), the better are the chances for reliable communication.

a. Selection of media. Wherever several transmission media are available, the technical controller should select the one that provides the best S/N for important message traffic.

(1) Radio propagation predictions help the technical controller to select the most reliable transmission frequencies. The predictions tell him in advance which frequencies will most likely provide him with reliable communication circuits. However, there is no guarantee that the predictions will always hold true. Sudden ionospheric disturbances always add elements of doubt to the success of HF long-distance radio communication. Of all the radio frequencies in the spectrum, only those in the HF range offer long-distance transmission at economical levels of transmitting output power without resorting to frequent relay stations. There are times when communications in the HF band becomes nearly impossible. For this reason the Department of Defense has developed and installed a satellite communication system that does not depend upon the ionosphere.

(2) Experience has shown that satellite communication systems consistently provide the highest quality long-distance communication in spite of the relatively low power used in the ground terminal transmitters. This quality and reliability results from a combination of line-of-sight transmission paths,

directional antennas, frequency modulation, and low-noise high-gain receivers. Primarily the greatest improvement in the signal is due to the line-of-sight transmission path. Moreover, frequencies used are so high that they penetrate the ionosphere. Since the radio waves are neither reflected nor seriously refracted, they are relatively independent of the vagaries of the ionosphere.

b. Techniques. At the high frequencies used for long-distance communication, the S/N can be improved by a number of techniques, most of which are applied to the radio receiving station. The radio receiving station primarily determines the action to be taken and when that action should occur. The radio receiving operator is the first to know when the signal quality deteriorates to dangerous levels. He receives his warning by frequent fades and a rise in noise level. The radio receiver can do little about the noise that rides on the signal when the signal arrives. However, receiver design greatly reduces the amount of internally produced noise, especially the "front-end" noise. Specially designed radio receivers include RF preamplifier stages called parametric amplifiers. These high-gain low-noise amplifiers are to be found in satellite communication ground terminals and tropospheric scatter terminals. A list of techniques used to improve the S/N in HF long-distance radio communication follows.

(1) Radio transmitter path.

(a) Directional antennas. A directional antenna at the transmitting station beams most of the radiated energy in the direction of the receiving station. A directional antenna at the receiving station limits the beamwidth of the received radio signal to the direction from which the radio signals arrive.

(b) Radio propagation predictions. Radio propagation predictions inform the technical controller and radio receiving operator which frequencies will most likely provide the strongest signal for the time of day and season of the year.

(2) Radio transmitter.

(a) Single-sideband transmission. Single-sideband (SSB) transmission provides a stronger received signal than double-sideband transmission because most of the available power is concentrated in the intelligence-bearing portion of the signal. Further, the absence of a strong carrier prevents heterodyning with adjacent signals, as well as minimizing

distortion that occurs when the carrier fades during selective fading periods.

(b) Increase in power output. Although an increase in radiated output power does improve the S/N, the improvement is not spectacular. Moreover, when the fading conditions create an absence of signal at the receiving station, no increase in power can improve the S/N.

(c) Reduction of bandwidth. By reducing the signal bandwidth at the transmitter, the receiver bandwidth can be narrowed a like amount, improving the S/N by the numerical value of bandwidth decrease. In other words, if the signal bandwidth is reduced to one-half its former value, the S/N is improved by a factor of two.

(d) Change of transmitter frequency. The change of transmitter frequency in line with radio propagation predictions is a very effective method of improving the S/N. The frequency-changing process is a completely coordinated activity under control of the two communicating technical controllers, who are alerted to the need for frequency change by the radio receiving operators.

(3) Radio receiver.

(a) Circuit. A triple-conversion superheterodyne circuit is normally used in HF radio receivers to achieve the necessary selectivity and sensitivity.

(b) AGC. Automatic gain control (AGC) helps the radio receiver to maintain a relatively constant output in the presence of fading. In SSB reception, the reduced pilot carrier normally furnishes the input signal for the AGC action. The AGC voltage is proportional to the strength of the carrier.

(c) AFC. Automatic frequency control (AFC) helps to keep the receiver tuned precisely to the received pilot carrier in SSB reception, thus minimizing the effects of transmitter frequency drift as well as stabilizing the value of AGC voltage developed from the pilot carrier. When radio receivers and transmitters use compatible frequency synthesizers, the importance of AFC is minimal.

(4) Terminal equipment.

(a) Narrow-band filters. The bandpass of each filter in the terminal equipment is designed to pass only the signal components needed to convey the information desired and to ignore other frequencies on either side of the bandpass.

(b) Peak limiters. Peak limiters reduce the effect of noise on the signal by clipping off the noise peaks above the desired peak level of signal. However, peak limiters can be used only on signals that use constant amplitude, such as frequency-modulated (FM), frequency-shift-keyed (FSK), or pulse-code-modulated (PCM) signals. Peak limiters cannot be used on voice or amplitude-modulated (AM) signals because peak clipping distorts the quality of AM signals.

c. Meaning of S/N. The ratio of the amplitude of the desired signal level to the amplitude of noise level at a given point in time. A favorable ratio is one in which the desired signal level always exceeds the noise by a comfortable margin.

(1) The human ear is a poor judge of the S/N because the ear is not frequency sensitive; it hears all frequencies within its range. If you were to listen to the output of a wide-band radio receiver with a pair of earphones, you would hear both signal and noise together. Your ear cannot separate signal from noise.

(2) To isolate the signal from background noise, frequency-selecting devices must be used, the simplest being a filter. In this way a communication channel using a narrow-band input filter hears only that noise which passes through the filter along with the signal. The S/N in this case is the ratio of the desired signal level passing through the filter compared with the noise falling within the bandpass filter.

(3) There are times when it would appear to the receiving operator that the sound of the received signal is so badly smothered in noise that communication seems almost hopeless, yet the telegraph terminal may be producing perfect copy on the teletypewriters. A terminal can perform in this manner because of the succession of narrow-band filters and limiters in each channel circuit. The presence of these narrow-band filters explains the superiority of VF telegraph channels for reliable communication as compared with telephone communication under noisy operating conditions.

(4) If the received signal is strong, the noise must likewise be strong to affect it. If the signal is weak, a weak noise can affect it. In other words, S/N expresses the relationship between the signal level and the noise level, and has nothing to do with the individual values of signal level or noise level.

d. Voice communication. Voice communication is unreliable during high noise levels encountered on the long-distance transmission path when conditions are poor. The reason for this is that the voice channel uses a relatively wide input filter, and the ear is incapable of selecting the voice signal out of the noise across the voiceband.

e. AM vs FM. The question may be asked, "if FM has an inherent noise-reduction feature, why not use FM on the HF band?" The answer lies not in the technology but in the number of users. The HF bands are so crowded that stations must conduct their communication in relatively narrow bands.

This precludes the use of FM because each FM signal consumes relatively large segments of the spectrum. Conversely, the crowded conditions of the HF band assure the continuation of narrow-band AM on the HF band. On a comparative basis, an FM station consumes at least 50 kHz for one voice signal, while a twin-sideband (TSB) AM signal can carry four voice signals in no more than 12 kHz of spectrum.

Learning Event 5: INTERFERENCE.

1. Radio interference. The two most effective ways of overcoming interference on radio systems is to stabilize the radio transmitter output signals, and to train operators to respect frequency assignments.

a. Recent advances in radio transmitter design feature frequency synthesizers. All frequencies produced by a frequency synthesizer are stabilized by a master oscillator, and therefore have comparable frequency stability.

b. Radio operators must select and use only those frequencies that are assigned by higher authority. They must also operate their sets to minimize transmission over greater distances than intended by using specific antenna types and stated output power.

(1) AM signals. One annoying source of interference between conventional AM signals is caused by carrier heterodyne. This means that when the carriers of two adjacent AM signals heterodyne at radio frequency, the resulting audio beat after demodulation falls within the bandpass of the radio receiver output. Single-sideband transmission largely eliminates this problem because little, if any, carrier power is transmitted.

(2) FM signals. When two FM signals interfere, the stronger of the two signals predominates, to the detriment of the weaker. When AFC is used, the receiver will retune to pick up the stronger of the two signals. Further, the limiters within the receiver will respond most readily to the stronger of two input signals. Heterodyning seldom occurs between FM signals.

Learning Event 6: DISTORTION.

The amount of distortion appearing within the received signal is an indication of system linearity. A system could have a low S/N and, at the same time, be useless for communication because of high distortion levels. Moreover, when distortion exceeds minimum allowable levels, it becomes necessary to minimize it through a cooperative effort by system personnel under supervision of the technical controller. Further, the type of distortion and its effects are related to the type of signal being transmitted.

a. Hearing distortion. The human ear is a poor indicator of distortion, since the ear hears everything within the signal. Electrical instruments are therefore necessary to measure the distortion. The distortion is first measured at the transmitting end, and then the receiving end. The increase in measured distortion is the amount created by the transmission path and the receiving equipment.

b. Harmonic distortion. The presence of frequencies at the output (receive) of a channel, caused by non-linearities within the channel, which are related to a single applied frequency at the input (transmit) of a channel. When a single frequency is transmitted through a channel, if no distortion of the signal occurs, the signal at the output of the channel will contain only the original frequency transmitted. But, if non-linear distortion occurs in the channel, new frequencies are produced which are harmonically related to the fundamental single frequency applied.

c. Intermodulation products. Intermodulation products (crosstalk) are frequencies that are created by interaction of the distortion products in the presence of a nonlinear circuit element. The test for intermodulation products must therefore be performed by the use of two sine-wave signals differing in frequency but having identical amplitude. If a third frequency is created by this interaction, its level is a measure of the circuit nonlinearity. The ratio of the third frequency signal level to either one of the two equal level test tones is called

the signal-to-distortion ratio (S/D). The frequency of the third signal is chosen to reflect the interaction between the second harmonic of one frequency with the fundamental of the other. This test is especially important for high-powered SSB radio transmitters.

Example: Two frequencies, 1,575 Hz and 1,000 Hz, are fed into the input of an SSB transmitter. If distortion is present, intermodulation will occur among all frequencies developed. Among these frequencies is the second harmonic of 1,000 Hz, which is 2,000 Hz. The difference between the 1,575-Hz and the 2,000-Hz harmonic is now 425 Hz. If we filter out the 425-Hz signal and measure its level, we will have an indication of how badly the input signals are being distorted and intermixed.

Learning Event 7: LONG-DISTANCE COMMUNICATIONS NETWORKS.

Long-distance communications networks are combinations of long-lines cable, line-of-sight radio and satellite communication systems. An example, a message traveling from Washington, D.C., to Frankfurt, GER may travel any one of a number of ways. During its travel the message must pass through a number of points where the systems join. These junctures are generally called interfaces. Since each of the communication systems has a different set of characteristics, each circuit must be conditioned prior to interconnection. Failure to properly condition the circuit results in distorted and/or noisy signals. And once signals are distorted, nothing can be done to remove the distortion products; the only remedy is to compensate for their effects. Technical controllers have the task of directing the circuit conditioning procedures, and for checking the distortion of communication circuits that are routed through their facilities.

Learning Event 8: CIRCUIT CONDITIONING.

When audio signals travel over a communication channel, they may be affected by variation in amplitude and phase. Circuit conditioning therefore is an attempt to return the received signal to as nearly its original condition as possible. Variation in the original frequency is not likely, but the amplitude may vary at different frequencies. Circuit conditioning involves processes of equalization, amplification, delay compensation, and frequency translation. The techniques of circuit conditioning always involve the measurement of signal levels. This is usually accomplished by measuring the level with

respect to a normal standard of 1 milliwatt (mw), designated 0 dBm on most decibel meters. Higher levels than 0 dBm carry a plus (+) sign, and lower levels carry a minus (-) sign.

a. Equalization. All telephone wires and cables have series inductance caused by magnetic fields around the wires and parallel capacitance between the wire pairs. The combination of series inductance and parallel capacitance causes the line to resemble a low-pass filter. Such a filter tends to pass the low frequencies readily but to attenuate the high frequencies. Correction of this condition is obtained by bridging circuit elements across the line so that they produce the exact opposite effect to the line constants. Inserting these circuit elements constitutes the process of equalization, which is always accomplished at the receiving end of the line. The result of equalizing is to attenuate the low frequencies and raise the high-frequency level. Technically, this is accomplished by restoring the phase shift between current and voltage to zero across the entire range of line frequencies; in other words, current and voltage are now in phase. The equalizing procedure always introduces some loss of signal power, so an amplifier normally follows each equalizer in the signal path. The amplifier is designed to raise the equalizer output signal level to that required by the terminating device.

b. Delay compensation. Theoretically, transfer of the current and voltage elements of a signal takes place instantaneously at the transmitting end of a circuit. Consequently there is no delay in power transfer. However, as the signal travels down the line, the constants of inductance and capacitance take their toll of signal quality by shifting current and voltage components of the signal. When the signal arrives at its destination, the phase relationship is different from when the signal was originally transmitted, and therefore the power within the signal is delayed in time. The result of this change is a variation of the signal's characteristics at different frequencies within the signal. The waveshape of the signal is therefore different when received than when transmitted. Obviously, the signal is now distorted. The correction technique involves the bridging of circuits containing inductance and capacitance across the line to offset the effect of line characteristics which caused the delay. This is the principle of delay compensation. Delay compensation techniques are analogous to equalization techniques, except that different testing devices are used. Delay has the greatest effect on digital signals because of the change in pulse waveshape caused by delay.

c. Transition delay. In an ideal signal pulse, the change between two levels occurs instantaneously. Consequently the transition time between the two limits of the pulse is zero. When that ideal pulse travels through a device having inductance or capacitance, phase shift causes a delay in recognition time of that pulse by the receiving device; The time delay from the start of the transition to the time the receiving device senses the change is called the transition delay. Delay compensation is used to minimize the variation in transition delay; that is, make all delays approximately equal to the longest one. In this way the variation in transition delay is minimal. It should be apparent that if the beginning transition has a different length from the ending transition, the pulse has changed length so far as pulse recognition is concerned. Whenever transition delays are unequal, pulse lengths vary and the received message will suffer. These principles hold true for telegraph, pulse-code modulation, or any other form of pulse transmission. Moreover, the effect is related to the length of the pulses. The higher the speed of pulse transmission, the shorter are the pulses, and thus the greater is the effect a given transition delay has on signal quality. Transition delay is a characteristic of a circuit and is therefore an indication of circuit quality. The quality of a circuit determines the quality of the signal passing through it. The term transition delay is normally used in reference to DC signal pulses, while envelope delay is normally used in reference to signal pulses derived from modulation of an AC (VF) carrier wave. When a voice channel is conditioned for a voice circuit, and a digital circuit is routed over the channel, the channel must be checked for envelope delay.

d. Frequency translation. When a technical controller attempts to interface two communication circuits, he sometimes finds signals other than communication signals. Moreover, these special-duty signals sometimes occur at different frequencies. If such frequencies are not identical in the two circuits to be interfaced, frequency translating devices will have to be incorporated in the interfacing facilities. These special-duty signals are used for signaling, ringing, switching, or testing.

Learning Event 9: TELEGRAPH SIGNAL QUALITY

Unlike telephone distortion, which you can detect by poor sound quality, telegraph distortion does not make its presence known until it becomes so bad as to cause the teletypewriters to misprint. Because of this fact, one of the major duties of a technical controller is to periodically measure the distortion in the DC receive telegraph loops. Only in this way can he determine that signal quality is deteriorating. If he waits until misprinting occurs, he has delayed too long; the channel

must be removed from service until the trouble is cleared. The technical controller must understand that when the circuit distorts the telegraph signals, little can be done to remove the distortion. Part of his job is to report the existence of the distortion and to compensate for its effect whenever he can. The task of finding and removing the source of distortion belongs to the equipment technician. Moreover, removing the cause of distortion is a far more useful operating technique than compensating for the effects.

a. Sources of telegraph distortion. Telegraph signal quality can be impaired anywhere along the communication system, from message transmission to message reception. The communication system may include cable circuits, radio circuits, and carrier channels, as well as the terminating teletypewriter sets. Telegraph signal quality can also be impaired by interfacing communication circuits and signals that are not compatible.

(1) Teletypewriter sets. The driving motors of teletypewriter sets must rotate at the same speed to print good copy. Minor speed differences can be accommodated by the synchronizing scheme of the telegraph signals. Major differences in motor speed must be corrected before the system can be turned over to traffic. Moreover, the selecting mechanism within each printer must "see" and correctly interpret the information from the received signal pulses. If system analysis proves that motor speeds are correct and the teletypewriters are free of signal distortion, the remaining distortion in the system is created within the facilities that interconnect the teletypewriters.

(2) Information transfer. The telegraph signal code used for teletypewriter communication consists of a series of DC pulses in a prearranged code. The intelligence conveyed by the code is included within the space-to-mark and mark-to-space transitions. As the pulses travel through a communication facility, the change in pulse waveshape causes the delays in transitions. Likewise, improper loop current and maladjustment of equipment items can cause variations in transition time. However, as long as enough of the pulse arrives to be recognized by the terminating device, the message should be printed correctly. Misprinting occurs when the transitions are displaced in time beyond the capability of the printer to interpret the code combinations correctly.

(3) Channel bandwidth of telegraph carrier terminal. When DC telegraph signals enter a channel of telegraph carrier equipment, the information contained within the telegraph pulse transitions is impressed on the carrier. The rate of occurrence of these

transitions is related to the speed of transmission. Likewise, the expanse of sidebands developed in the modulation process are related to the speed of transmission. Since each channel contains a send filter to limit the expanse of sidebands, the bandwidth of this filter limits the speed of transmission that the channel can carry. The higher the transmission speed, the wider must be the channel bandwidth. Increasing the transmission speed beyond the channel capability is almost certain to result in excessive telegraph distortion.

b. Data-transmission. The use of data signals is rapidly increasing in military communications. Since data pulses are much shorter than normal telegraph pulses, more pulses are used in the code and the keying rate is faster. Existing telegraph terminals designed for teletypewriter transmission cannot be used directly for data, but changes can be made to accommodate the higher speed data signals. Four methods that can be used to accommodate the data signals in a communication system using telegraph terminals are:

(1) Use telegraph carrier equipment having wide-band channels.

(2) Slow down the rate of keying to the equivalent rate of telegraph transmission so that the signals may pass over a narrowband channel of existing terminal equipment.

(3) Replace existing telegraph carrier terminals with terminals having enlarged bandwidth capabilities.

(4) Use serial-parallel transmission.

c. Serial-Parallel transmission. Operating principles of serial-parallel transmission are illustrated in figure 1. This is a system to make use of low-speed narrow-band channels of a multichannel frequency-division multiplexing (FDM) terminal for the purpose of transmitting high-speed data signals.

(1) Figure 1 illustrates one-way transmission only, using a two-wire line. When four-wire transmission is used, a full-duplex circuit can be established, each two-wire line being used for one direction of transmission.

(2) Each station has a compatible serial-parallel converter. In minimizing distortion it is most important that the converter at the east station be synchronized to the incoming signal so that the switching occurs in the same sequence as the received signal pulse. As a signal pulse arrives in the DC receive loop of a given channel, the converter is sequentially switched to sample the output of that channel. Failure to maintain synchronization causes distortion of that received signal.

(3) The converter attached to the DC send loops at the west station sequentially switches the very short data pulses from the data bit stream into telegraph terminal channels. Besides the switching function, the send converter extends each code pulse to the length of a normal teletypewriter signal for transmission over the corresponding channel of the terminal.

(4) Conversely, the receiving converter samples the appropriate channel having a normal-length teletypewriter pulse, and produces a short data pulse. Sequential switching reconstructs the data bit stream for use in the data receiving terminal.

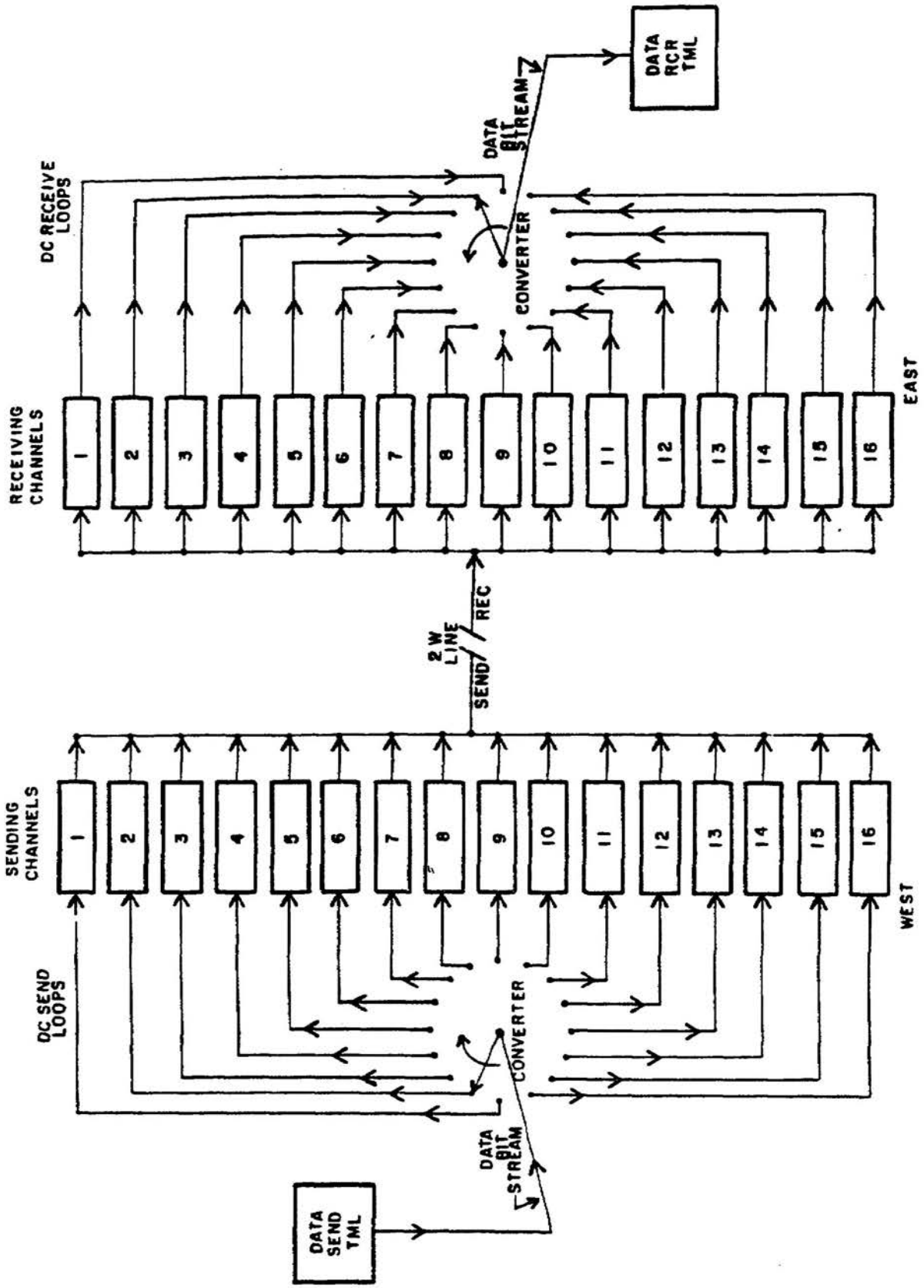


Figure 1. Serial-parallel conversion, block diagram.

Learning Event 10: COMMUNICATIONS CONTROL.

Every communications system, regardless of size or complexity, must have centralized control. Lacking such control, the maze of comminations channels that make-up a modern communications system become hopelessly entangled. Under proper supervision, direction and control, these circuits are made to serve all users of the DCS System.

a. Technical control centers are located at each end of a multichannel system. Facilities are provided for operators or technician to communicate with each other. Using the order wire channel, they coordinate their activities to achieve maximum use of available facilities.

b. The technical controller must have a thorough knowledge of the varied types of communications systems and equipment in use today. The technical controllers at the different facilities must work together as a team to provide communications that meet or exceed the Defense Communications Agency (DCA) standards.

Learning Event 11: CATEGORIES OF DCS SERVICE.

a. Many types of communication services are provided by the Defense Communications System (DCS) under control and supervision of DCA. To aid DCA in establishing control and supervision, DCA publishes a DCS Technical Schedule to provide a common language for DCS circuit ordering, allocation, activation, operation and maintenance. They serve two primary purposes:

(1) Service description tables. Provides a guide for the circuit engineer to identify standard circuit performance parameters used to support a particular service.

(2) Circuit parameter tables. Provides the allocator/engineer with a shorthand method of specifying quality control circuit parameters in the Telecommunication Service Order (TSO) without providing details of the required performance.

b. The technical schedule includes a brief description of the type of service to be provided along with the circuit parameter code.

c. User-To-User circuits. Is a circuit of any organization, unit, office or individual that has equipment connected to a DCS circuit and uses the DCS for communications. Basically it is a term used to identify two user terminals directly connected through the DCS.

d. Automatic switching networks. These networks include automatic voice (AUTOVON), automatic digital networks (AUTODIN) and automatic secure voice communications (AUTOSEVOCOM).

e. Circuit requirements. The requirements of circuit quality vary with the type of service. The least stringent requirements are imposed on voice (telephone) circuits, and the most stringent requirements being placed on the automatic switching networks.

f. Quality requirement categories. The required categories of parameters for circuit quality generally include frequency response, envelope delay, noise, crosstalk and harmonics. Some parameters are more important to voice communications while some are more important to data communications. Especially important to data communications are the parameters of frequency response and envelope delay. Equalization is therefore one of the first operations a technical controller will perform to condition a voice circuit for high-speed data communications. Equalization may not be critical in voice circuits such as ringdown and telephone, but it is always essential in automatic switching networks passing over voice facilities and usually require equalization.

Learning Event 12: STANDARDS FOR NOISE MEASUREMENT.

a. Noise weighting. Noise weighting is a commercially developed rating system to identify the characteristics of the type of a receiving element in a telephone handset (subset). Each type of receiving element has a characteristic curve that relates the interfering effect of noise on a received voice signal. Data for these curves were arrived at through statistical analysis of listener's reports of voice understandability in the presence of known values of noise amplitude and frequency. Noise weightings therefore refer to specific handset (subset) types and for this reason must carry identification of the receiving element in the handset. Noise-measuring test sets are calibrated in weightings similar to those given the telephone receiver. When tests are made for other than voice understandability (data, for example), the test set must indicate the limits of the frequency band over which the weighting is specified.

(1) F1A-Line weighting. F1A represents the class of weighting used in a noise-measuring set to measure noise on a line that is terminated by a 302-type or similar subset.

(2) HAl-Receiving weighting. HAl-receiver weighting is used in a noise measuring set to measure noise across the HAl receiver of a 302-type or similar subset.

(3) C-Message weighting. This is noise weighting used in a test set to measure noise on a line that is terminated by a 500-type or similar subset. C-message is the most widely used type of weighting in military voice communication.

(4) Flat weighting. The amplitude-frequency characteristic of a noise-measuring set is flat over a specified frequency range, which must be stated in descriptions of the equipment. The range is usually controlled by an input filter.

(5) Psophometric weighting. This is a type of noise weighting established by the Consultative Committee for International Telephone and Telegraph (CCITT) for use in a noise measuring set known as a psophometer. The shape of this characteristic is virtually identical with that of F1A weighting. Psophometric weighting is used mostly in Europe and is seldom employed in the United States.

b. Units of noise measurement. The units that follow are used to express weighted and unweighted circuit noise. These units include terms used in American as well as international practice.

(1) DBa (dBrn adjusted). DBa (dBrn) is the noise level in a circuit having F1A-line or HA1-receiver weighting. 0 dBa is noise power of 3.16 picowatts (-85 dBm), equivalent to 0 dBrn (-90 dm or 1 picowatt with C-message weighting) adjusted to F1A weighting.

NOTE: A 1-milliwatt 1,000-Hz tone will read +85 dBa. However, the same power in white noise, randomly distributed over a 3-kHz band (nominally 300 to 3,300 Hz) will read 3 dB less, or +82 dBa.

(2) DBa (F1A). DBa (F1A) is the noise level measured on a line by a noise-measuring set having F1A-line weighting.

(3) DBa (HA1). Weighted noise power across the receiver of a 302-type or similar subset measured by a test set having HA1 receiver weighting is identified as dBa (HA1).

(4) DBa0. The power level of noise can be referred to the signal level at a particular point in the circuit. In this case, the signal level becomes the reference (0). Noise measured in dBa with respect to this point is called dBa0.

NOTE: It is preferred to convert circuit noise readings from dBa to dBa0, as this makes it unnecessary to know or state the relative transmission level at point of actual measurement.

(5) DBm. This term refers to power level with respect to milliwatt, whatever the source. Thus dBm can represent either signal level, noise level, or a combination of both. The power level of 1 milliwatt is indicated by the term 0 dm.

NOTE: In American practice, unweighted measurement is normally understood, applicable to a certain bandwidth which must be stated or implied. In European practice, psophometric weighting may be implied, as indicated by content; equivalent to dBm0p, which is preferred. Only American practice is discussed in this text.

(6) DBm0. In noise power measurement, noise power in dBm can be referred to the normal signal level at a point in the circuit. This measurement is designated dBm0.

(7) DBrn. Reference noise (rn) signifies a level 90 dB below 0 dBm, or -90 dBm (1 picowatt). 0 dBrn is therefore equivalent to -90 dBm of noise power, while 0dBm is equivalent to +90 dBrn. When C-message weighting is used to measure noise across the VF band, noise level equivalent of 0 dBm (1 milliwatt) at 1,000 Hz is +88 dBrn.

(8) DBrn (C-message).. Weighting should always be indicated in parenthesis. DBrn (C-message) weighting is level of noise measured on a line-measuring set with that weighting. Noise power is usually abbreviated dBrnc when so weighted, and parentheses thereby become unnecessary.

(9) DBrnc0. When noise power is measured on a set with C-message weighting and referred to the normal signal level passing the point of measure, the noise level is quoted as dBrnc0.

(10) DBrn (f_1-f_2). This expression indicates the measured noise level compared with the reference of -90 dBm (0 dBrn) when measured across the voiceband shown within the parentheses.

c. Calculations. Noise levels in dBa and darn are measured by test sets. Noise levels in dBa0 and dBrnc0 are not measured; they are calculated by taking into account meter readings, circuit weightings, and relative signal levels.

LESSON 1
PRACTICE EXERCISE

In each of the following exercises, select the ONE answer that BEST completes the statement or answers the question. Indicate your solution by circling the correct letter in the subcourse booklet.

1. Every communication circuit suffers from the effects of noise, interference, distortion, and attenuation. Good communication quality is indicated by the absence of

a. distortion, noise, and attenuation.

b. interference, distortion, and noise.

c. noise, attenuation, and interference.

d. attenuation, interference, and distortion.

2. Technicians use the term "white" noise to differentiate its effects from the effects of other noise types. White noise results from the cumulative effects of

a. impulse, thermal, and cosmic noise.

b. cosmic, atmospheric, and impulse noise.

c. thermal, cosmic, and atmospheric noise.

d. atmospheric, impulse, and thermal noise.

3. The signal-to-noise ratio, total noise, signal power, and amplifier gain have their effects on the reliability of communication. The limiting factor of reliability is the

a. signal-to-noise ratio.

b. amplifier gain.

c. signal power.

d. total noise.

4. A combination of a resistor and capacitor is commonly used to reduce electrical noise. This combination of components will usually be found connected across

a. movable parts of shielding.

b. radio receiver to ground leads.

c. telegraph relay keying contacts.

d. commutators of motors and generators.

5. Peak limiters improve S/N in terminal equipment that demodulates an FM-type signal. However, peak limiters cannot be used on AM signals because limiters

a. distort the quality of the signals.

b. limit the bandpass and prevent passage of all signal elements.

c. balance out the carrier, leaving only the sidebands to heterodyne and create distortion.

d. remove selected noise components and in the process remove desired signal components.

6. When two adjacent AM signals are received, the carriers sometimes interact and cause heterodyning. This condition usually causes

a. an audio beat frequency within the bandpass of the radio receiver output signal.

b. the receiver to pick up the stronger of the two signals, to the detriment of the weaker.

c. an increase in the background noise due to the reduction of AGC voltage.

d. the peak limiters to react, thus improving the S/N by clipping the heterodyning noise.

7. Intermodulation products are detrimental to good communication quality. The level of intermodulation product is an indication of

a. signal-to-noise ration.

b. signal-to-distortion ratio.

c. distortion on a single test tone.

d. heterodyning between the two test signals.

8. To determine the level of harmonic distortion created by a circuit, you must feed into the circuit a

a. single tone frequency and listen to the output signal.

b. wide-band input signal and note the change in output level.

c. single tone frequency and isolate the harmonic with filter.

d. wide-band input signal and measure the level of intermodulation product.

9. Each circuit using an equalizer also normally uses an amplifier because the equalizer

a. attenuates frequencies unevenly.

b. always translates the line frequency.

c. bridges circuit elements across the line.

d. always introduces some loss of signal power.

10. Equalization of a line is always accomplished at the receiving end of a circuit because the technician cannot know how the line has affected the signal until after the signal has passed through the line. Equalization is necessary because most telephone lines

a. exhibit characteristics of high-pass filters.

b. have series capacitance and parallel inductance.

c. pass low frequencies readily but impede high frequencies.

d. have distributed resistance throughout the length of the lines.

11. Assume that a circuit has been equalized to meet all requirements for satisfactory voice communication. If VF data signals are to be sent over this circuit, the circuit conditioning technician must also check for

a. uniform frequency response.

b. variation in envelope delay.

c. overall line loss.

d. interference.

12. Telegraph carrier sending channels may cause degrading of the signal quality in the presence of rising transmission speeds. The primary cause for this change in signal quality is the

a. shortened transition delays.

b. bandwidth of the send filters.

c. time delay in relay operation.

d. response of the electronic keying circuits.

13. The serial-parallel method of operating through FDM communication terminals is intended to allow high-speed data signals to be transmitted over

a. wide-band voice channels.

b. narrow-band voice channels.

c. wide-band telegraph channels.

d. narrow-band telegraph channels.

14. The most important principle in minimizing distortion in serial-parallel operation is

a. sequential switching of the data bit stream.

b. sampling of the output signal of the receiving channel.

c. lengthening of the short data pulses to normal-length tt pulses.

d. synchronizing the receiving converter with the received pulse sequence.

15. Technical schedules published by DCA show circuit parameters for all the services provided by the DCS. The most stringent circuit parameters are required for

a. facsimile.

b. nonsecure voice.

c. automatic switching networks.

d. automatic secure voice communication.

16. Circuit parameters are important in establishing standards for circuit quality. Circuit parameters that are especially important to high-speed data communication over voice circuits are

a. noise and crosstalk.

b. interference and noise.

c. amplitude-Frequency response and interference.

d. frequency response and envelope delay.

17. The need for equalization depends on the type of service and the line facilities. Equalization is always essential for circuits in automatic

a. secure voice circuits passing over a wide-band radio set.

b. digital networks passing through a wide-band modem.

c. switching networks passing over voice facilities.

d. voice networks passing through coaxial cable.

18. Assume that a noise measuring test set has a switch position marked C-message. This switch arranges the circuit in the test set to give it characteristics of a

a. 500-type subset.

b. 302-type subset.

c. bandpass input filter.

d. line terminated in a 302-type subset.

19. Technical control personnel must be able to recognize the significance of terminology abbreviations such as dBm, dBr, dBa, and dBrn. The term which can be used to indicate the power level of either signal or noise is

a. dBrn.

b. dBr.

c. dBa.

d. dBm.

20. Assume that a noise reading of +68 dBrn (C-message) is obtained on a noise measuring test set. This indicates that the level is

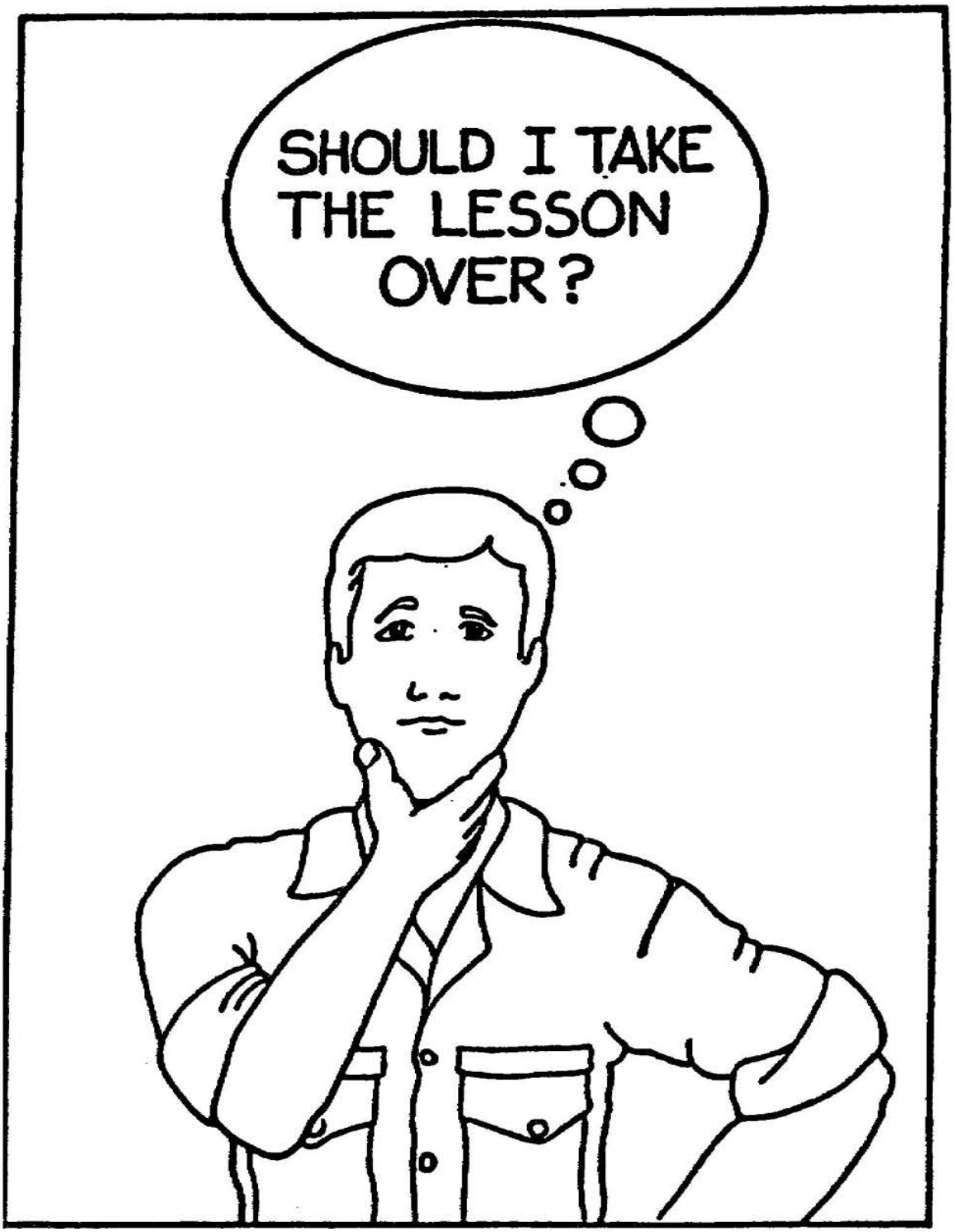
a. higher than 0 dBrn and the line is normally terminated by a 500-type subset.

b. lower than 0 dBrn and the line is normally terminated by a 302-type subset.

c. higher than 0 dBa and the line is terminated by a circuit that has a flat frequency response.

d. lower than dBa0 and the line is terminated by a resistor.

Check your answers with Lesson 1: Practice Exercise Solution Sheet (page 103) and make necessary corrections.


SHOULD I TAKE THE LESSON OVER?

LESSON 2
CONCEPTS OF CIRCUIT CONDITIONING

TASK: Describe the duties of technical controller, determine circuit parameters using the Defense Communication System (DCS) technical schedule, and if VF circuits meet selected parameters.

CONDITIONS: Given information about the duties of a technical controller, description of DCS technical schedule, and an extract from DCAC 300-175-9 of a DCS Technical Schedule.

STANDARDS: Demonstrate competency of the task skills and knowledge by responding to the multiple-choice practice exercise; select the ONE answer that BEST completes the statement or answers the question, covering concepts of circuit conditioning.

(This objective supports Tasks 113-616-3018, Test Circuit for Impulse Noise, TD-8; 113-616-3020, Test Circuit for Composite Data Transmission Level, TD-10; 113-616-3062, Determine Test Tone Level; 113-616-3075, Test Circuit for Basic Noise, TD-6; 113-616-3031, Perform In-Service QC Tests.)

REFERENCES: DCAC 310-70-1, Volume I, II, and III, Supplement 1 and 2 to Volume II, DCAC 300-175-9

Learning Event 1: THE THREE A'S OF CIRCUIT CONDITIONING.

The duties of a technical controller include three interrelated operations: Analyze, apply and adjust. Although the duties involved with circuit activations affect the circuit conditioner, responsibility for activation rest with the technical controller.

a. Analyze. Using testing devices, the circuit conditioner must be able to analyze new circuits prior to activation, and to analyze existing circuits for troubles when called upon to do so. Further, he must analyze telephone circuits to determine whether they can be conditioned to satisfy the needs for expanded high-speed service.

b. Apply. The circuit conditioner must be able to determine the need for correction, using specified test equipment items. Further, he must be able to select the corrective items needed to achieve the circuit requirements. He must also be able to apply circuit data furnished by the DCA.

c. Adjust. The circuit conditioner must be able to adjust corrective items so as to meet requirements of circuits and to use test items in verifying that requirements have been met. Corrective items on VF circuits include equalizers, pads, amplifiers, and terminating resistors. Corrective items on DC circuits include regenerative repeaters, relays, and pulse form restorers.

Learning Event 2: TOOLS FOR TEE CIRCUIT CONDITIONER.

To provide useful results in circuit conditioning at least three basic conditions must be present, as shown in figure 2. Test sets, corrective devices, and DCA specifications must all be present at the bay or patching panel where circuit conditioning procedures will be applied.

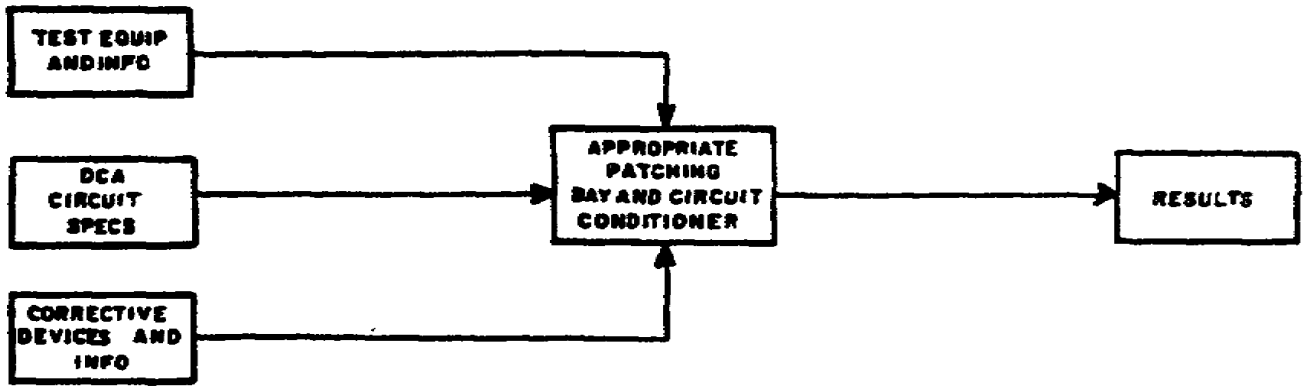


Figure 2. Basic conditions for circuit conditioning, block diagram.

a. Test equipment and information. Needed test equipment items will normally be found at technical control centers and communication nodal points. Because of their large size and weight, most test items are rack mounted. Since connections with circuits are normally made through patching panels, the test sets are usually provided with jack terminations. Jacks and patchcords simplify the process of connecting the test sets to circuits. An important component of each test equipment item is the instruction manual; no test set is complete without it. More important, however, is the knowledge concerning the use of the test set.

This applies to circuit conditioners, technical controllers, and assisting personnel alike. This knowledge is especially important for the technical controller because he will often be directing an operation from a distance. He must know the capabilities, limitations, and the normal method of operation for each item of test equipment.

b. DCA circuit specifications. The characteristics of circuits will normally be specified by the DCA in the form of a Telecommunication Service Order (TSO). These characteristics are defined in DCA publications. A large variety of technical information is available from the DCA. All DCS station headquarters maintain a library of these publications. They can be ordered through channels from the Defense Communications Agency. Inspectors normally examine the DCA publications library in each station to assure completeness.

c. Corrective devices and information. The principal corrective device for VF circuits is an equalizer. Each equalizer must have an instruction book for the circuit conditioner to use since each equalizer is individually calibrated. An amplifier having sufficient bandwidth for the service specified follows each equalizer in the circuit to make up total line and equalizer loss. Part of the equalizer is an impedance-matching transformer that is used to match the equalizer to the circuit.

d. Location. Circuit conditioning is always performed at the terminating point (receiving point) of a circuit, and the receiving termination of most interface locations. When the overall circuit consists of several sections having differing characteristics, each subordinate circuit must be conditioned prior to interconnecting to the next circuit. The purpose of this procedure is to make every section compatible with the next in as many circuit parameters as possible. It is nearly impossible to condition an entire circuit consisting of interconnected sections at only one receiving termination of the overall circuit.

Learning Event 3: PRECAUTIONS IN TESTING VF CIRCUITS.

When using test techniques specified for circuit conditioning, the technician must exercise precautions so as to gain satisfactory results while at the same time insuring the safety of equipment and personnel involved.

a. Read and study. There is no substitute for knowledge about the test equipment used in circuit conditioning. To gain this knowledge, technicians must read and study all available information. This must be done before starting any test so that the test method and equipment operation is understood. Knowledge will also give an awareness of any special measures that should be taken to safeguard equipment and personnel.

b. Preliminary check. Circuits or segments of circuits being tested must not interfere with traffic flow, but must otherwise be under normal working conditions. Failure to test under working conditions may require retesting. As a preliminary to other test procedures, a listening check of the circuit with either high-impedance headphones or an oscilloscope may be useful in indicating the presence or absence of tones or other conditions that could interfere with test results. Further, a normal test of the line for general line condition (shorts, foreign battery, grounds, etc.) with a wire test set is definitely in order as a preliminary check.

c. Grounds. When test equipment and circuits under test require ground connections, the connections must be made to a common ground point to avoid creating ground return loops which can pick up interfering currents.

d. Coordination. Circuit conditioning can be successful only as long as technicians at both ends of a circuit know what is going on. Communication between them must be established and maintained during the entire operation. A circuit for this purpose must be independent of the order wire, because the technical controller will use the order wire. Further, both technicians involved in circuit conditioning must realize that the one at the receiving termination is responsible for all circuit conditioning actions in his direction of signal flow. Control of the circuit reverts to the other terminal for the opposite direction of signal flow. Coordination between the conditioning technicians and the technical controllers is an important function, too, so as to safeguard channels of traffic flow. A technician who carelessly interrupts flow of traffic irritates his associated technical controller.

e. Treatment of equipment. Treat equipment with great care; these are precision scientific instruments. Do not allow unskilled personnel to operate the test sets. Test equipment connections and switch positions must be checked thoroughly before applying power, and power should come from a filtered power source when possible. Further, test equipment must be properly calibrated at sufficiently close intervals to assure accurate readings.

f. Impedance matching. Input and output impedances of the test sets must match the circuits to which they are applied. Likewise, the input and output impedances of the corrective devices must match the circuits and test sets. Failure to observe these precautions will cause inaccurate level readings. Where impedances do not match, the technician will have to install an impedance-matching transformer or similar device.

g. Transmission level. All levels must be adjusted to their proper values before circuit conditioning tests are started. This procedure has two benefits; it assures accuracy of results, and it protects sensitive instruments against possible damage.

h. Location for tests of line condition. The most positive and direct method for determining the condition of a telephone line is to pass a signal through it and observe the line's effect on the quality of the signal. In determining the line's condition by this dynamic method, the technician must assure himself that no equipment is included in the initial test. Equipment which is capable of either improving the signal quality or degrading it gives the technician a false indication of the line's true condition. One way the technician can assure himself that he is observing a true line condition is to disconnect the line from the circuit at the cable patch bay. The signal therefore cannot enter any equipment in the technical control center. A careful analysis of the signal quality thereby gives the technician a correct interpretation of line condition.

(1) A list of equipment in a technical control center that may affect signal quality includes pads, amplifiers, signaling units, and echo suppressors. Compandors, which also affect test results, are normally part of equipment items; unless these items are included in the tests, compandors need not be considered.

(2) The technician has a choice of LINE, EQUIP, and MON jacks in the receive cable patch bay. When he uses the LINE jack, he lifts the line away from all circuits thus eliminating the effect of equipment items on signal quality. He cannot lift the line at the EQUIP jack. He can, however, pick up the signal in MON jacks. The MON jacks are intended merely for monitoring and not to determine line condition because these jacks do not disconnect anything; they merely provide a point where test sets can monitor the signal with high-impedance instruments. The high impedance inputs of such test equipment assures the technician that the instruments will not load the circuit under test.

(3) Standard plug-in terminating resistors resembling patching plugs may be used as receive terminating devices at the LINE or EQUIP jacks. These resistors match the characteristic impedance of the receiving line at the patch panels, thus minimizing noise buildup in untested segments of the circuit and on the channels or lines under test.

Learning Event 4: PRECAUTIONS IN TESTING DC CIRCUITS.

Many of the precautions in regard to VF circuits apply also to DC circuits. The major difference is in the characteristics of signal/current. Where the important factors in VF transmission are level and frequency the important factors in DC transmission are the amount of current and its direction. DC circuits are normally tested at the DC patch bays which are remote from the VF bays, thus minimizing the possibility of crosspatching between VF and DC circuits. DC patching is normally performed in loop circuits of teletypewriter sets and telegraph terminal equipment. The lint side of a telegraph terminal is usually VF, so the rules for VF patching and testing apply here.

Learning Event 5: DESCRIPTION OF DCS TECHNICAL SCHEDULE AND SERVICE.

Selected samples of DCS technical schedules and codes are contained in the appendix, tables 1 through 5. These technical schedules are established by DCA, and published in DCAC 300-175-9. They are continually updated and modified as needed. The specification originates with a request for service by a user or potential user to satisfy the demands of the requested service.

a. The DCS technical schedule in table 1 is for government owned circuits. There are other technical schedules in DCAC 300-175-9 for communication circuits leased in CONUS, leased from AT&T, and leased from Western Union, but for this lesson we will stay with the government-owned circuits. Within table 1 is listed the circuit categories, circuit types and type of service for each circuit by item number.

(1) Circuit categories. Listed in table 1 are 10 circuit categories which have one or more circuit types listed under each category. They are:

(a) User-to-user circuits (category 1). User-to-user circuits is a type of service where the end instruments are directly connected through the DCS, point-to-point circuits. This category has four types of service, voice, facsimile, telegraph and data.

(b) Voice Frequency Carrier Telegraph (VFCT) Systems (category 2). Category 2 only has one type circuit/service, which is the VFCT.

(c) AUTOVON access lines (category 3). This category has three types of circuits/services which is voice grade or special grade that is used to access AUTODIN switches.

(d) AUTOVON trunks (category 4). Category 4 services are interswitching trunk circuits, voice grade or special grade used between automatic switches by category 3 users. They may be transoceanic circuits.

(e) AUTODIN access lines (category 5). AUTODIN access lines is a digital service used to access the DCS. They range from 75 baud DC keying lines to 4800 b/s. The 2400 b/s through 4800 b/s are used to access AUTODIN interswitching trunks.

(f) AUTODIN interswitching trunks (category 6). Interswitching trunks are a special grade digital, dedicated circuit between automatic switches. They are used by the 2400 b/s through 4800 b/s users of category 5.

(g) AUTOSEVOCOM access lines (category 7). This category of service is normally a 4-wire circuit, used to access the DCS and automatic switches. They are used between the secure voice terminal equipment and technical control facility.

(h) AUTOSEVOCOM trunks (category 8). This category normally services 2400 b/s or 50 kb/s secure voice, and may be a point-to-point or routed through automatic switching networks.

(i) Basic groups, 60-108 kHz (category 9). This category normally supports user-supplied Frequency Division Multiplex (FDM) of 60-108 kHz at group level between facilities (unconditioned). It also supports a conditioned 50 kb/s requirement between DCS facilities with the use of Government Furnished Equipment (GFE), data modems and data auxiliary sets, etc.

(j) Digital services (category 10). This category was designed to set standards for channels and circuits routed over digital transmission facilities, Pulse Code Modulation (PCM) and Time Division Multiplex (TDM) equipments. This type of service is more defined and explained in enclosure 8, table 1.

b. Enclosure 1, table 5 contains the cross reference between the item number of table 1 and the parameter codes. Each type of service in table 1 is assigned an item number. When it is necessary to determine a parameter code for a specific type of circuit/service, the item number of table 1 must be cross-referenced with the parameter code in table 5.

EXAMPLE: To determine the parameter code for a "nonsecure voice circuit" (the first type of service listed in table 1).

Locate the item number for the nonsecure voice circuit in the left column of table 1, which is 1A.

Turn to table 5 and locate 1A under the column labeled ITEM NUMBER. To the right of 1A in the column labeled CIRCUIT PARAMETER CODE, is listed the parameter code for the nonsecure voice circuit which is V1.

c. Enclosure 1, table 2 contains specific circuit parameters that correspond to the types of services listed in table 1 for voice circuits. This table contains the characteristics (type of test) by parameter codes. The type of tests (frequency response, envelope delay, etc.) are listed in the left column under characteristics. The next column contains the unit of measurement (dB, microseconds, degree, etc.). In the heading of the remaining columns are listed the parameter codes for the voice circuits of table 1. To determine the parameters of a specific voice circuit, locate the parameter code at the top of table 2. In the column, under the selected parameter code will be listed the parameters for the type of test listed in the left column.

EXAMPLE: Determine the parameters for a circuit assigned a V1 parameter code.

Step 1. Locate the V1 parameter code at the top of table 2.

Step 2. Locate the point under the V1 column that is parallel to the first test listed in the left column, which is frequency response. At that point will be listed the parameters for frequency response.

NOTE: The first parameter (-8 dB to +20 dB) listed is for non-secure voice circuits such as ringdown and telephone where the frequency spectrum tested is from 0.4 kHz to 2.8 kHz. The second parameter (-7 dB to +12 dB) listed is for voice circuits such as facsimile and DC, where the DC is converted to tone on a single channel basis for transmission over radio systems. The frequency spectrum tested for this type circuit is from 0.6 kHz to 2.4 kHz. Notice that the parameters are tighter for the single channel digital circuits.

Step 3. Under the V1 column move down to the next test listed, which is Maximum Envelope Delay Test. This test is not performed on a circuit assigned a V1 parameter code, because there is not any parameters listed in the column.

Step 4. Move down the column to the next test listed, which is Maximum Net Loss Variation. This test will be performed on V1 circuits because it has parameters listed in the column.

d. There is a total of 24 tests listed in DCAC 300-175-9 Extract, table 2, of which 16 are performed on voice circuits assigned V1 parameter codes. Continue the procedure used in the above example to determine which of the remaining tests must be performed on the circuit and the test parameters. Also the same procedure is used to determine which test will be performed on any voice circuit listed in table 1 and their parameters.

e. DCAC 300-175-9 Extract, Enclosure 1, tables 3 and 4 contain the required information needed to determine the parameters for voice circuits assigned X and Z parameter codes. The same procedure used in the example, also applies to these tables.

f. Circuit conditioning is normally performed to satisfy the circuit requirements, and nothing further. Exceeding this requirement takes additional time and perhaps additional equipment, as well as more frequent routine checks of circuit parameters. Since requirements for AUTOSEVOCOM are more stringent than for any other type of service, circuits conditioned to those requirements

can pass any inferior type of signal. However, conditioning all circuits to AUTOSEVOCOM requirements seems to be a waste of money and time. On the other hand, if circuits are to be switched between different types of service, it may be advantageous to condition each circuit to the highest requirement, namely AUTOSEVOCOM. Table 5 shows that one schedule may satisfy more than one type of service. An example is circuit parameter code D2, which is specified in items 1P, 2A and 5C for data, voice-frequency telegraph (VFCT), and AUTODIN, respectively. The regional control office of DCA selects the appropriate technical schedule and forwards the information to station personnel.

g. Upon receipt of a request for specified service by a subscriber, DCA prepares a Telecommunication Service Order (TSO) and forwards copies to the various facilities involved in providing the service. The TSO includes, among other items, a specification of parameters taken from the DCS technical schedules (appendix). The circuit conditioner then clears the circuit with the technical controller, and proceeds to condition it. When the circuit meets requirements of the parameter code indicated in the TSO, it is returned to the technical control.

h. Circuit parameter codes carrying letters of identification, including V, D, S, N, and Z. These generally signify voice, data, special grade, DC teletypewriter, and secure voice, respectively. The order of ascendancy is likewise V, D, S, and Z. A circuit conditioned for a D parameter code can serve for either D or V, but a V code cannot serve for D. Of course, any circuit conditioned for Z can serve any lower parameter, parameter code N is usually handled as a separate matter.

i. Frequency response (insertion loss). The most important circuit parameters in voice communications to the circuit conditioner are those parameters covering insertion loss and envelope delay. Where voice signals are transmitted, the insertion loss characteristic assumes the greater importance of the two. Where data signals are transmitted, the envelope delay characteristic is more important, but for now we will keep the discussion with frequency response.

(a) Channels having poor frequency response generally discriminate against frequencies toward the low and high ends of the channel bandwidth while favoring the frequencies near the midband. The resulting distortion of the composite signals are known as frequency-versus-amplitude distortion. Frequency-versus-amplitude distortion is caused by the electrical characteristics of communication system components.

(b) The human ear is fairly tolerant of frequency-versus-amplitude distortion; however, excessive distortion can degrade

quality and intelligibility in telephone service. The most serious effects are encountered in digital service when distortion of the individual signal elements (bits or pulses) cause errors in the receiving terminal equipment. Frequency-versus-amplitude distortion is a significant source of errors in digital service. The insertion loss measurement is important to ensure that the frequency response characteristic of a channel is adequate for its intended use and to permit operation of several channels in tandem without unacceptable degradation. Frequency-versus-amplitude distortion is not specified or measured as such. Instead, the frequency response characteristic of channels are specified in terms of insertion loss.

(c) Since channels may be engineered to provide loss or gain, insertion loss is a relative term which must be referred to the actual level, 1004 Hz (standard test frequency) for voice frequency channels. Insertion loss is not a measurable quality; it is calculated by finding the difference between the reference frequency and the actual frequency measured at the receive of a voice channel.

(d) Assume, for example, that an oscillator is used to send a test signal through a telephone line that terminates in a level meter. The oscillator is adjusted to place a level of +10 dBm into the line at three selected frequencies of 404 Hz, 1004 Hz and 2804 Hz. The results of the test are shown below. Total loss is the difference between the input level and the receive level of any frequency. Relative loss is the difference between the total loss at 1004 Hz and the total loss at the other two frequencies. To establish a reference, the loss at 1004 Hz is considered 0 dB; in this way, losses at the other frequencies can be quoted with respect to the reference (0 dB). The relative loss at 404 Hz is 8 dB less than the loss at 1004 Hz, so it carries the minus sign (-). The relative loss at 2804 Hz is 20 dB more than the loss at 1004 Hz, so it carries the plus sign (+).

Oscillator Frequency	Input Level	Receive Level	Total Loss	Relative Loss
404Hz	+10 dBm	-2 dBm	12 dB	-8 dB
1000Hz	+10 dBm	-10 dBm	20 dB	0 dB
2800Hz	+10 dBm	-30 dBm	40 dB	+20 dB

j. Listing of characteristics. Lettered items in the CHARACTERISTICS column of table 2 indicate the name of a test that the circuit conditioner must perform.

k. Practical applications of frequency response characteristic. Parameters of frequency response give the circuit conditioner a valuable tool for circuit analysis and adjustment of corrective equipment. The frequency response characteristic is listed under parameters in terms of decibel loss either greater than (+) or less than (-) the loss at 1004 Hz. The level reflects the opposite relationship; that is, the higher the loss the lower the level. Conversely, the lower the loss, the higher the level.

EXAMPLE 1. In the S1 parameter, the frequency response characteristic should not exceed the range of 2 dB less loss (-) at 0.3 kHz or 6 dB more loss (+) at 3.0 kHz than the loss at 1.04 kHz.

EXAMPLE 2. Assume that the output level of the circuit at 1.04 kHz is -2 dBm. What are the measured levels at 0.3 and 3.0 kHz for parameter S1? Less loss is equivalent to a higher level, and greater loss is equivalent to a lower 1.04 kHz, so the level will be 2 dB higher than -2 dBm, or 0 dBm. On the other hand, at 3.0 kHz there will be 6 dB more loss than at 1.04 kHz, so the level will be 6 dB below -2 dBm, or -8 dBm.

EXAMPLE 3. Assume that the output level of a circuit using parameter S1 at 1.04 kHz is -3 dBm, and that the output level at 0.5 kHz is -2.5 dBm and the output level at 2.8 kHz is -5 dBm. Does this circuit meet the requirements of parameter S1? The difference between -3 dBm at 1.04 kHz and -2.5 dBm at 0.5 kHz is no more than 0.5 dB, well within the requirement of no more than 1 dB less loss than at 1.04 kHz. The difference between -3 dBm at 1.04 kHz and -5 dBm at 2.8 kHz is 2 dB, well within the tolerance of 3 dB more loss than at 1.0 kHz.

1. Practical Application of Selected Parameters. Two additional characteristics that are also closely monitored by the technical controllers are maximum net loss variation and maximum allowable channel noise. The maximum net loss of a circuit is the total loss measured from the input of a sending station to the output of the receiving station. Specifically, it is the difference (loss) between the transmitted level and the receive level. The maximum

allowable channel noise is measured by a noise measuring set with C-message weighting. The unit of measurement is dBrnc0, which is noise power in dBrnc measured at a zero transmission level point.

EXAMPLE 1. Parameter S2 allows a maximum variation in net loss of 6 dB, 3 dB above or below the average received level. The level is taken at the test frequency of 1.4 kHz. If the average received level is -1 dBm, the received level must not rise above 2 dBm or fall below -4 dB at 1.04 kHz.

EXAMPLE 2. Noise level is usually given in terms of dBrnc0. This phrase refers to C-message weighting of a circuit whose noise level is compared with the transmission level point (TLP). Noise parameters are identical for all similar mileage distances in table 2 for schedules S1 through D2. All of these figures are positive, indicating that noise levels are above 0 dBrn. However, these figures are not levels; they are the decibel requirements of the parameters. If the requirement is 37 dBrn, the actual noise level is 37 dB above -90 dBm. Numerically, it is the difference between -90 and 37, or -53 dBm.

EXAMPLE 3. Assume that a communication circuit is 980 miles long and the measured noise level is -38 dBm. Does the circuit meet requirements? No, because the difference between -38 and -90 dBm is 52 dB, greater than the 41 dB allowed in the parameters.

Learning Event 6: EXPANDED CIRCUIT PARAMETERS.

a. Circuit parameters are greatly expanded to provide AUTOSEVOCOM service
schedules Z1, Z2, and Z3 in tables 3 and 4 establish the parameters for 10 to 50,000 Hz over metallic facilities without regenerators. These parameters are based on full-duplex operation using four-wire termination, with impedance and source load at 135 ohms. The level of the baseband input signal is 0 dBm, which is 1.04 volts peak to peak at 135 ohms impedance.

b. Circuit parameters are also greatly expanded for the 50 kilobit/secencrypted voice transmission system (AUTOSEVOCOM) designed to provide service within a bandwidth of 48 kHz over long-distance carrier facilities. With this method of use, four normal voice channels in the carrier terminal are replaced by one 48-kHz special service band. Schedule Z4 shown in table 4 shows the parameters for the carrier method of operation.

LESSON 2
PRACTICE EXERCISE

In each of the following exercises, select the one answer that best completes the statement or answers the question. Indicate your answer by circling the correct letter in your subcourse booklet.

1. The duties of a circuit conditioner can be described by the three A's which stand for

a. analyze, apply, and adjust.

b. apply, adjust, and activate.

c. adjust, activate, and analyze.

d. activate, analyze, and apply.

2. One characteristic of most test equipment items located in a control facility is that they usually have

a. jack terminations to simplify making connections.

b. battery-operated power sources for maximum portability.

c. counters instead of meters to simplify recording procedures.

d. solid-state circuits to minimize weight and size for ease in carrying.

3. One of the reasons a circuit conditioner must thoroughly know all aspects of his profession is that he may be called upon to control procedures from a distance. This situation comes about because

a. he may have to direct operations from every transmitting point in the system.

b. circuit conditioning may have to be done at the receiving termination of every nodal point.

c. all circuit conditioning is performed principally at receiving terminations of multisection communication circuits.

d. he needs reports on errors in the traffic flowing over the conditioned circuit.

4. One function of terminating resistors that resemble patching plugs is to reduce noise buildup on lines during tests. These plugs are used to

a. ground the line through a resistance.

b. dissipate the noise power developed on lines.

c. load the lines during the equalizing process.

d. terminate lines in their characteristic impedance.

5. Communication must be maintained between circuit conditioners working at opposite ends of a system to assure coordination of their activities. The normal communication channel between them is through

a. ground return.

b. the order wire circuit.

c. the line being conditioned.

d. a circuit independent of the order wire.

6. A circuit conditioner should listen on the line with a high-impedance headset before starting conditioning procedures.

The purpose of this preliminary check is to determine whether

a. signals have correct levels.

b. the line needs equalization.

c. the line is open, shorted, or grounded.

d. signals that could interfere with tests might be present on the line.

7. While the circuit conditioner tests DC circuits, he must use certain precautions to protect the test equipment. These precautions include knowledge of the

a. amount and direction of current flow.

b. signal level and amount of current flow.

c. amount of current flow and signal frequency.

d. signal frequency and direction of current flow.

8. Circuit planners in the DCA normally designate the parameters at the time that the

a. circuits are initially activated.

b. technical controller patches the circuits.

c. subscriber requests a particular type of service.

d. circuit ends are terminated in corresponding equipment items.

9. The DCA lists several circuit parameters in defining voice circuit requirements. The most important circuit parameter listed is the

a. insertion loss characteristic.

b. envelope-delay distortion.

c. intermodulation distortion.

d. noise level.

SITUATION

Circuit parameters are listed in tables given in the 300-175-9 Extracts. To be a successful circuit conditioner you must be familiar with them and be aware of their significance.

Exercises 10 through 16 are based on this situation.

10. Three services that use circuit parameter code VI (tables 1 and 5) are

a. 066-063 IBM, facsimile, and nonsecure voice.

b. facsimile, nonsecure voice, and voice-grade AUTOVON.

c. voice-grade AUTOVON, voice-grade interswitch, and 066-063 IBM.

d. nonsecure voice, voice-grade AUTOVON and voice-grade interswitch trunks.

11. Assume that a subscriber has shown a need for 100-wpm DC teletypewriter service. The DCA circuit planner therefore specifies in the Technical Service Order parameter code

a. N1.

b. N2.

c. N3.

d. D2.

12. Assume that the technical controller has available circuits carrying parameter codes V1, S1, S2, V2, D1 and Z1. Which incoming circuits can be patched over the outgoing circuit carrying D1 parameter code?

a. V1 and V2.

b. V2 and S1.

c. S1 and S2.

d. S2 and Z1.

13. Assume that the Telecommunication Service Order indicates the need for the schedule Z4 parameter. This parameter indicates that the carrier system should be conditioned for

a. 50-kilobit/baseband.

b. 20-kilobit/second data rate.

c. voice at a level of -17.5 dBm.

d. voice at a level of -21 dBm.

14. The parameter code that covers trunk circuits utilized between two switchboards is the

a. Z1 parameter code.

b. Z3 parameter code.

c. Z2 parameter code.

d. X1 parameter code.

15. Assume that in comparing four conditioned circuits you find one has less than 3000 microsecond delay characteristic. This circuit will satisfy the circuit parameter of delay for schedule

a. D2 parameter code.

b. S1 parameter code.

c. S3 parameter code.

d. N3 parameter code.

16. Schedules Z1, Z2, and Z3 have some similarities. However, schedule Z3 (table 4) is different in that it is intended for transmission of

a. clear-text voice over metallic facilities.

b. VF telegraph over telephone carrier channels.

c. DC telegraph over VF telegraph carrier channels.

d. trunk circuits used between two switchboards.

SITUATION (Cont)

As part of your training, you have been told to check an incoming line for nonsecure voice transmission. When you measure the incoming signal test tone of 1,004 Hz, you find a level of +2 dBm at the output of having -26 dB gain. Refer to DCAC 300-175-9 Extract table 2 for circuit parameters.

Exercises 17 through 20 are based on this continued situation.

17. To meet requirements for nonsecure voice transmission (code V1), the Signal level should be no higher

a. +10 dBm at 0.4 kHz, and no lower than -18 dBm at 2.8 kHz.

b. -8 dBm at 0.4 kHz, and no higher than +20 dBm at 2.8 kHz.

c. -8 dBm at 0.4 kHz, and no lower than -20 dBm at 2.8 kHz.

d. -10 dBm at 4.0 kHz, and no higher than +18 dBm at 2.8 kHz.

18. The maximum net loss is the total loss between the input level of the sending terminal as compared with the output level of the receiving terminal. To meet requirements of the maximum net loss variation parameter, the sending terminal must be transmitting at a level that lies between the limits of

a. -6 dBm and +2 dBm.

b. -6 dBm and -2 dBm.

c. +6 dBm and -2 dBm.

d. +6 dBm and +2 dBm.

19. The level of noise allowed on a particular channel is 46 dBrn, what would that noise level be equal to in dBm?

a. -56 dBm.

b. -54 dBm.

c. -46 dBm.

d. -44 dBm.

20. Assume that you want to find a parameter that states relative loss for a subscriber-to-switch circuit in 50-kHz wide-band service over metallic facilities. You will look in parameter code

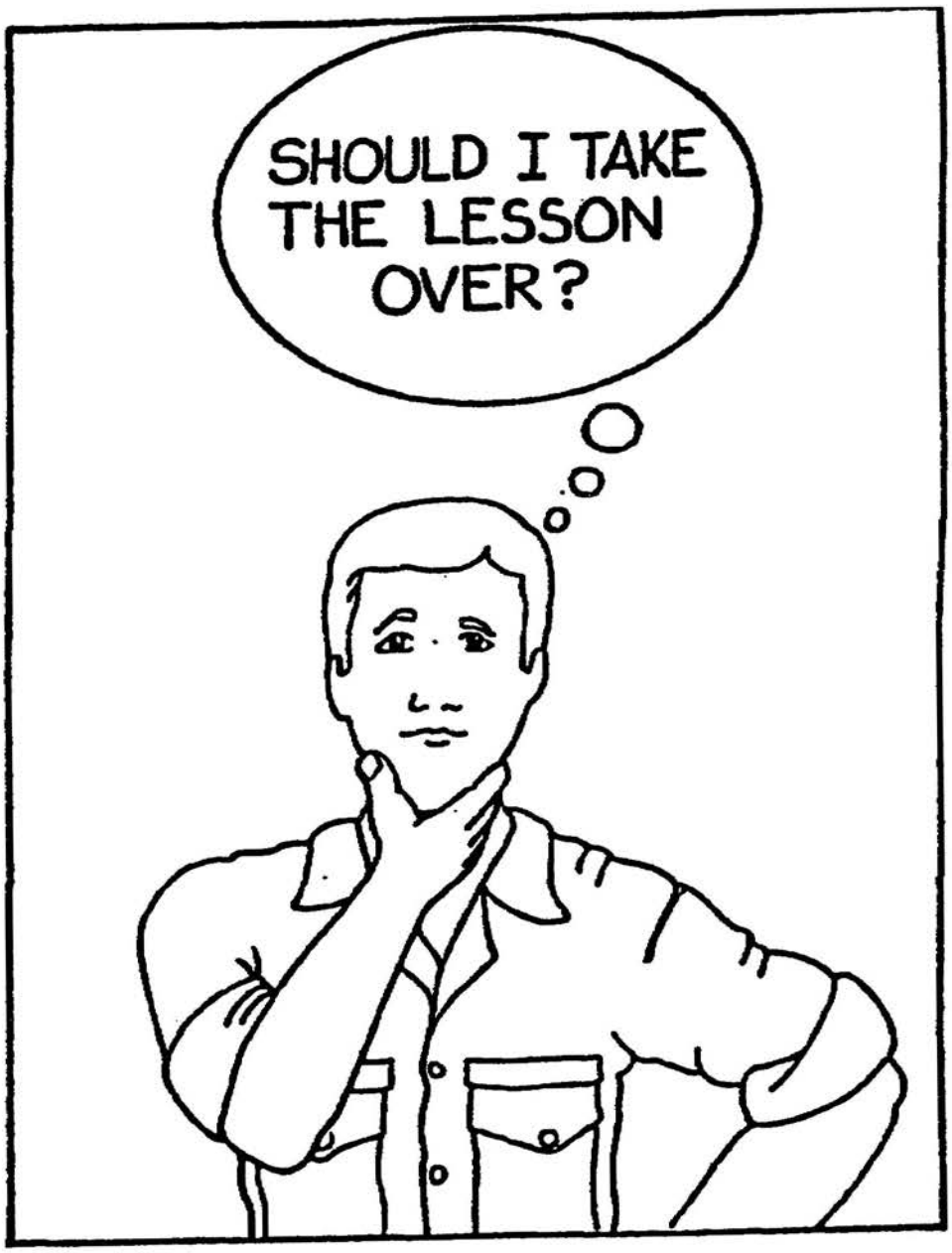
a. Z1.

b. Z2.

C. Z3.

d. Z4.

Check your answers with Lesson 2: Practice Exercise Solution Sheet (page 104) and make necessary corrections.


SHOULD I TAKE THE LESSON OVER?

LESSON 3
CIRCUIT CONDITIONING TEST SETS

TASK: Identify the type of the test equipment, describe the function of the front panel controls and characteristics of the test and equalizer equipment.

CONDITIONS: Given information about the type, use, characteristics and function of the front panel controls for the test and equalizer equipment used in circuit conditioning.

STANDARDS: Demonstrate competency of the task skills and knowledge by responding to the multiple-choice practice exercise; select the ONE answer that BEST completes the statement or answers the question, covering circuit conditioning test sets.

(This objective supports Tasks 113-616-3018, Test Circuit for Impulse Noise, TD-8; 113-616-3020, Test Circuit for Composite Data Transmission Level, TD-10; 113-616-3026, Determine Test Tone Level; 113-616-3075, Test Circuit for Basic Noise, TD-6; 113-616--3031, Perform In-Service QC Tests.)

REFERENCES: Manufacturer's Manual for Transmission Impairment Measuring Set (TIMS) 4940A, TM 11-6625-602-12, Test Set Telephone AN/USM-181, TM 11-6625-2463-12, Noise-Level Measuring Set, TTS-37B, TM 11-6625-2658-12, Oscilloscope AN/USM-281C, TM 11-5805-673-14 & P, Equalizer Group OA-8804

Learning Event 1: TYPES OF TEST INSTRUMENTS.

Within the DCS technical schedules, the large number of parameters that have to be satisfied for successful circuit conditioning requires a large variety of generalized and specialized test equipment items. Further, some test items are limited to use by circuit conditioners, while others are used by both circuit conditioners and technical controllers. Almost all listed instruments use dynamic testing principles; they perform their functions by measuring or indicating signal characteristics.

a. General test equipment. Generalized test equipment items include several commonly used sets that are found in most technical control facilities. These include oscilloscopes, VF signal generators, decibel meters, volume unit indicators, voltmeters,

millimeters, telegraph distortion test sets, impulse noise counters, noise measuring sets, and telegraph transmission test sets.

b. Specialized test equipment. Specialized test equipment needed by circuit conditioners over and above the generalized test equipment include envelope delay test sets, wave analyzers, X-Y recorders, spectrum analyzers, and equalizers. Although equalizers are corrective devices, they are adjusted more by circuit conditioners than by technical controllers.

c. Types of test sets. Wherever standard military test sets are available, they should be used. However, where standard military items are incapable of measuring parameters required by DCA schedules, commercial items must be procured. Many of these commercial items are "off-the-shelf" merchandise. Since a number of manufacturers produce satisfactory items for this purpose, the list of items may vary from one station to another. When selecting such sets, the primary considerations must be the capability to measure the parameters in question, and reliability of operation. Other items, such as appearance, size, power requirements, mounting arrangements, and placements of controls, are secondary considerations.

Learning Event 2: CORRECTIVE DEVICES.

The principal corrective device used to condition VF communication circuits is an equalizer. For maximum utility in circuits that may be required to carry data and secure voice signals, the equalizer should be capable of correcting for envelope delay as well as the usual function in VF circuits for correcting for amplitude-frequency distortion.

Learning Event 3: TRANSMISSION IMPAIRMENT MEASURING SET, MODEL 4940A

Transmission impairment measuring test set, Model 4940A shown in figure 3 is designed to measure data handling capability of voice communication channels.

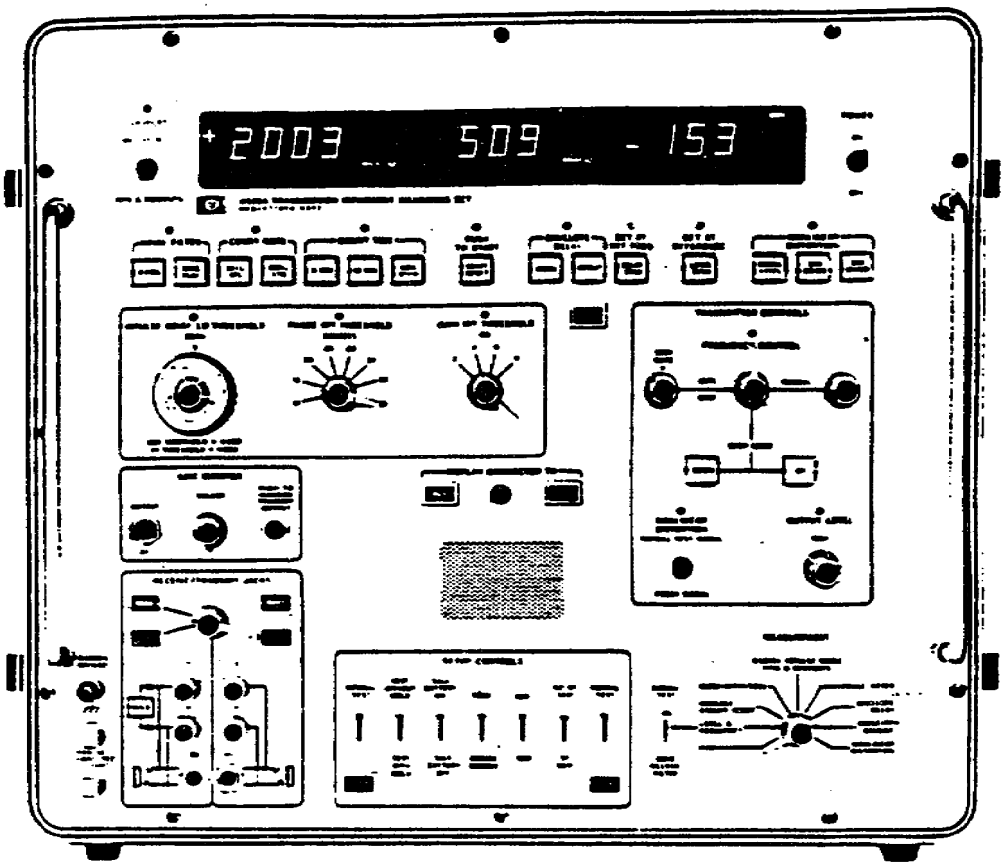
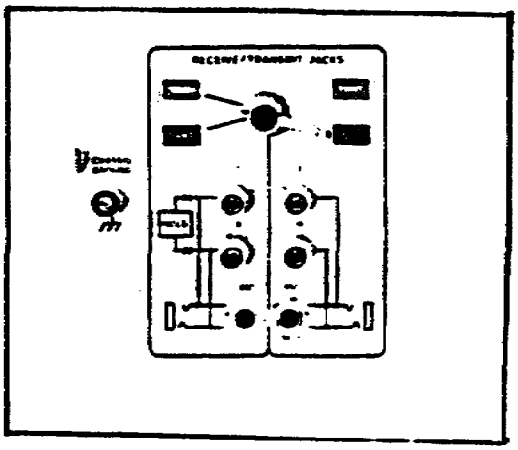


Figure 3. Transmission Impairment Measuring Set (TIMS) HP Model 4940A

The TIMS is one of the latest impairment test sets acquired by the Army for testing communication circuits. It can be used to test 16 or more different parameter tests. The standard model is mounted in a fiberglass case, however it can be rack mounted if the rack mounting kit is requested from the factory when the test set is purchased. The test set is divided into two main sections, the transmit and receive. The transmit section is used to transmit the test signals required to perform any of the 16 tests you wish to perform. The receive section is used to measure any of the 16 receive test signals and has the capability of giving you a digital readout of three parameters at one time.

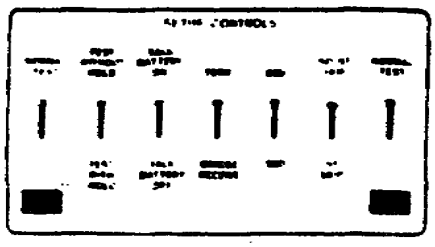
a. Operational controls. All of the controls and jacks are located on the front of the test set for easy access. They are arranged in sections that correspond to the test that may be performed and the setup procedures.

(1) Receive/transmit jacks. The receive/transmit jack section is used to connect the test set to the circuit under test. This section has two 310 jacks, four binding posts, rotary switch, four indicator lights and a chassis grounding post. The 310 jacks are used to connect the test set to a circuit using patch cords at a patch bay. The binding post may be used when there is a requirement to perform a test where there are not any patch bays, then individual conductors may be used to connect the test set to a distribution frame or cable. The rotary switch is a two position switch used to reverse the transmit and receive of the jacks, in the up position the left jack is connected to the receive (REC) and the right jack is connected to the transmit (TRMT) of the circuit under test. In the down position the jacks are reversed (This procedure applies to four-wire circuits). When testing a two-wire circuit the left jack will be used. The indicator lights indicate which jacks are TRMT and REC. The chassis ground post is to be used for ground when a ground cannot be made through the sleeve of a 310 plug or the binding post are used to perform a test.

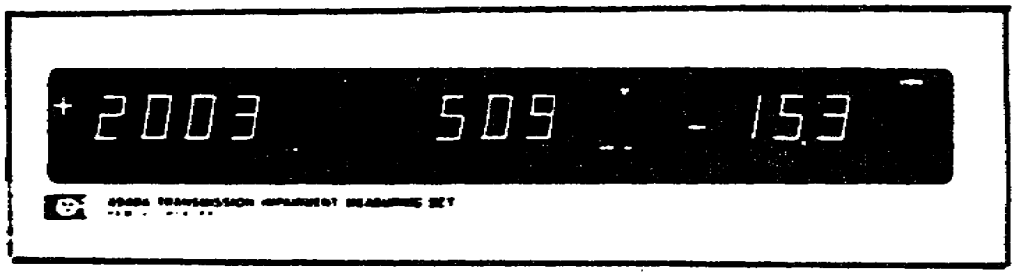


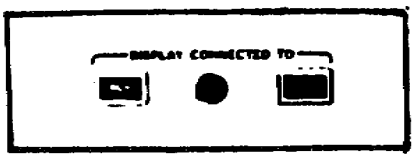
(2) Setup controls. The setup controls consist of nine two position switches and two indicator lights. The indicator lights operate in conjunction with the NORMAL TEST/DIAL TALK and NORMAL TEST/SELF CHECK switches. The switches are self explanatory, when

the NORMAL TEST/DIAL TALK switch is in the DIAL TALK position, the test set is set up to test dial circuits. If the NORMAL TEST/SELF CHECK switch is in the SELF CHECK position the test set is in the self check mode and the controller can check its operation for each test, frequency response, phase jitter, etc.

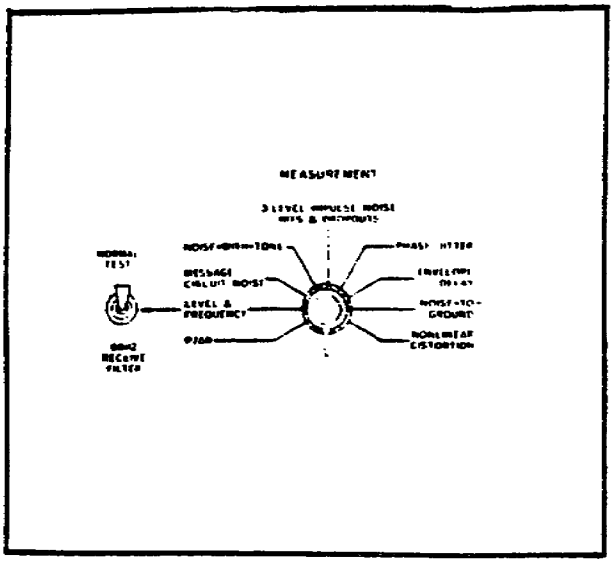


(3) Digital display. The digital display provides a three position readout of quantitative information for all measurements. The range, polarity and decimal points are automatic. The display also indicates underrange and overrange by displaying a minus (-) sign for underrange and a plus (+) sign for overrange. It can display up up to three parameter measurements simultaneous, for example, when performing frequency response, the specific frequency in hertz and the level of the frequency will be displayed. The transmit test signals may be monitored as well as the receive signals by switching the DISPLAY CONNECTED TO switch to transmit (TRMT). The indicator light on each side of the switch will indicate which signal is being monitored, receive (REC) or transmit (TRMT).





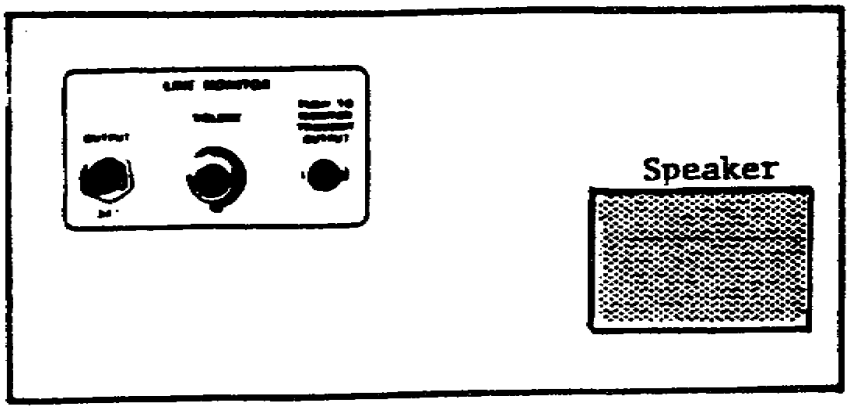
(4) Measurement switch. The MEASUREMENT switch is used to select the type of test to be performed, signal loss, frequency response, phase jitter, etc. This section does have one special feature, a switch labeled NORMAL TEST and 60 Hz RECEIVE FILTER. It is spring loaded and remains in the "normal test" position, but when it is depressed to the "60 Hz receive filter" position, it filters out any 60 Hz power hum that may be on the circuit or line under test. This reduces level measurement error caused by AC power related noise.



(5) Line monitor. The line monitor section permits you to listen to the circuit under test, transmit or receive. The circuit may be monitored using the built in speaker or by using a handset plugged into the output jack.

(a) The output jack also may be used to connect an analyzer or oscilloscope to further analyze the circuit under test.

(b) The line monitor section is connected to the receive side of the circuit. To monitor the transmit side of the circuit under test, the PRESS TO MONITOR TRANSMIT switch has to be pressed. The volume controls the output to the speaker and output jack.

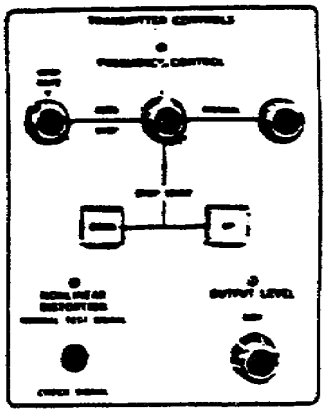


(6) Transmitter controls. The transmitter control section consists of a FREQUENCY CONTROL switch, OUTPUT LEVEL control and NONLINEAR DISTORTION SWITCH.

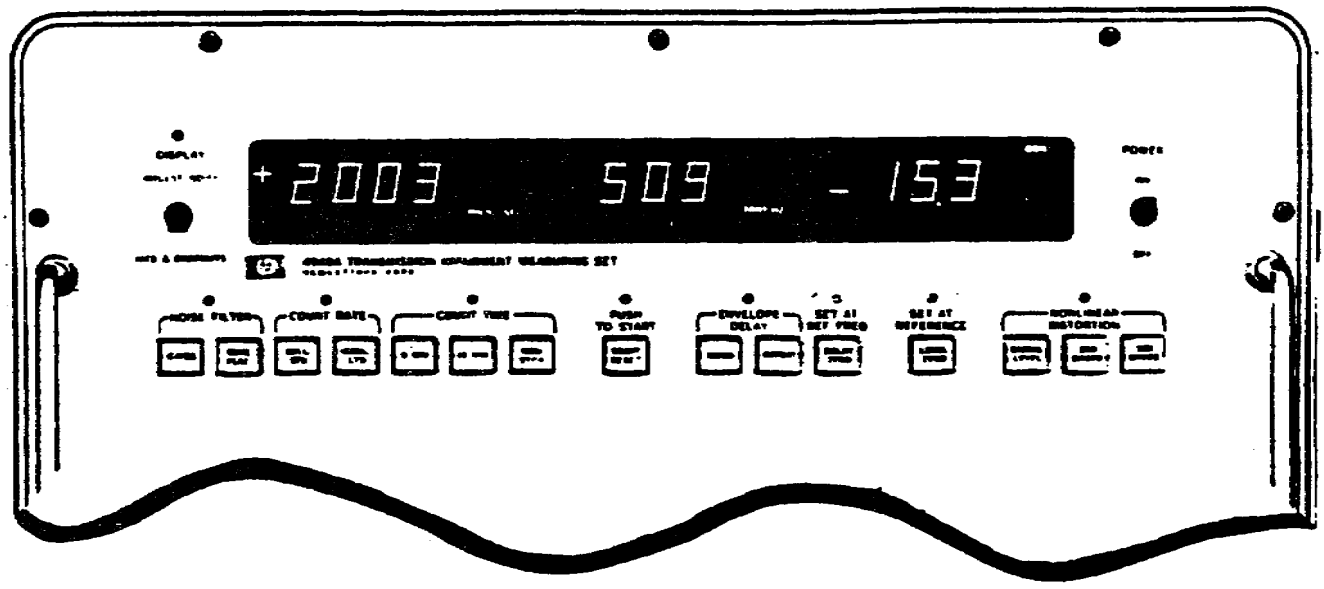
(a) Frequency control switch. The frequency control switch selects the transmit frequency control mode. When it is in the AUTO STEP position, the transmit frequency is automatically stepped in 100 Hz increments from 204 Hz to 3904 Hz at a rate controlled by the step rate control. In the STEPPED 100 hZ position, the frequency in manually stepped in 100 Hz increments from 204 Hz to 3904 Hz by pressing the UP or DOWN push button switches. When the switch is in the MANUAL position the transmit frequency is continuously variable over the range of 200 Hz to 3904 Hz by adjusting the manual control.

(b) Output level control. The output level control is a variable control, that will vary the transmitted test signal from a -49 dBm to a +10 dBm.

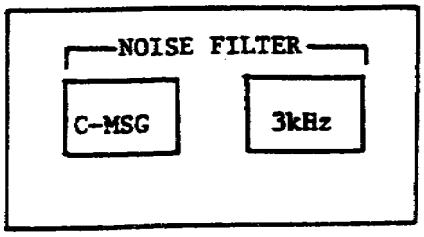
(c) Nonlinear distortion key. The nonlinear distortion key permits comparison of a normal test signal and the receive test signal so that compensation of background noise can be made.



(7) There is a row of 15 push button switches located just below the digital readout indicator, which is used in conjunction with the measuring switch. The functions of these switches are outlined in the following paragraphs.



(a) -Noise filter. The first two switches are used to select C-MESSAGE WEIGHTING or 3 kHz FLAT when performing noise measurements on a circuit.

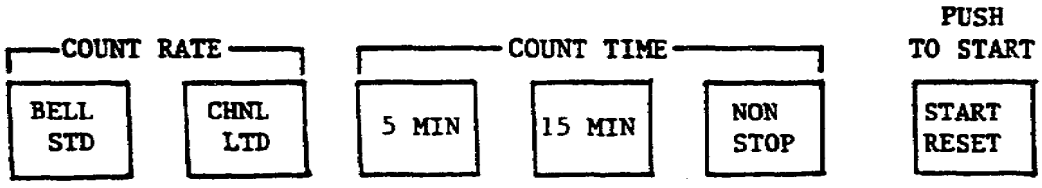


(b) The COUNT RATE, COUNT TIME and PUSH TO START switches are used when performing three-level impulse noise hits and dropout measurements.

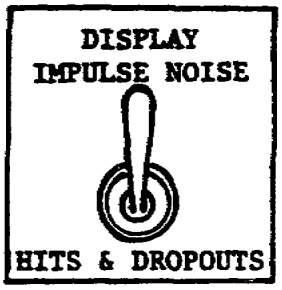
1. Count rate. When the BELL STD switch is depressed, the maximum total count is limited to seven hits per second, but when the CHNL LTD is depressed, total count is only limited by the channel bandwidth and selected noise filter within the test set.

2. Count time. When the 5 MIN or 15 MIN switches are depressed the test set will count the noise hit/dropouts for 5 to 15 minutes respectively before stopping, but if the NON STOP switch is depressed it will count the hits/dropouts continuously until the reset switch is depressed.

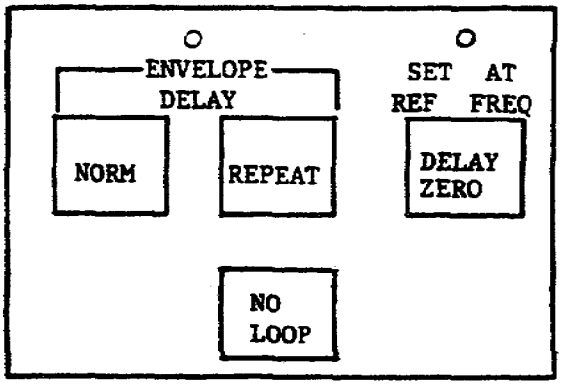
(c) Push to start. This switch must be depressed to start the test or restart the test.



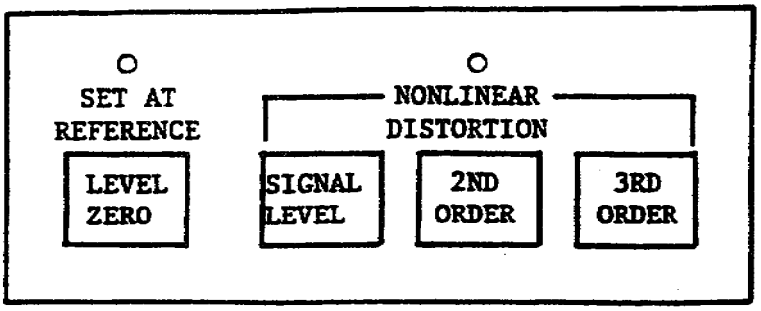
(d) Display key. The display switch (key) also works in conjunction with the three-level impulse noise hits and dropout test. When the switch is in the IMPULSE NOISE position, the display will show the hits at the low, medium (MID) and high frequency spectrum of the channel under test. When the switch is in the HIT & DROPOUT position the display will show phase hits, dropouts and gain hits.



(e) Envelope delay. The envelope delay section consists of one indicator light and three push button switches that are used to perform return reference envelope delay test. The indicator light (NO LOOP) will be illuminated any time the envelope delay loop is broken, or the signal is attenuated to the point that an accurate reading cannot be made. The DELAY NORM AND REPEAT push button switches, determine whether the test set will be used to measure envelope delay (NORM) or retransmit (REPEAT) the delay signal received from the distant end. The DELAY ZERO push button switch is used in conjunction with the envelope delay measurements. When the test set is adjusted to the desired reference frequency, pressing the DELAY ZERO switch will establish a zero microsecond delay reference. All delay measurements are then relative to this reference point.



(f) Nonlinear distortion. The nonlinear distortion section consists of four push button switches. The SIGNAL LEVEL switch, when depressed allows measurement of the total nonlinear distortion test signal. The 2ND ORDER and 3RD ORDER switches, when depressed measures only the second and third order product of the test signal, respectively. The LEVEL ZERO push button switch is used in conjunction with the level and frequency. When the test set is adjusted to the desired reference frequency, pressing the LEVEL ZERO switch will establish a zero dB reference. All the following measurements will be made in dB relative to this reference point. If the LEVEL ZERO switch is not pressed, all measurements will be absolute dBr.



b. The nonlinear distortion test is an optional test, and must be requested when ordering the test set, so these switches may not be on all the TIMS.

c. The TIMS can be used to perform the majority of the parameter tests established to maintain daily operation of DCS voice circuits. There is approximately 16 or more tests that can be performed using the TIMS. Some of the tests are:

(1) Frequency response.

(2) Background noise.

(3) Basic noise C-message.

(4) Noise-to-ground.

(5) Nonlinear distortion.

(6) Peak-to-average ratio (P/AR).

(7) Single tone interference.

(8) Harmonic distortion.

(9) Phase jitter.

(10) Impulse noise hits and drop.

(11) Envelope delay.

(12) Phase hits and gain hits.

(13) Maximum change in audio frequency.

Learning Event 4: TIMS REPLACEMENT.

Even though it is possible to perform several test using the TIMS, which may eliminate several pieces of test equipment, it is not feasible to replace all the test equipment at the same time. In some cases it may take several years at some facilities, therefore the remainder of this lesson will be devoted to some of the other types of test equipments that may be in use today in some of the technical control facilities.

Learning Event 5: TELEPHONE TEST SET AN/USM-181.

Telephone Test Set AN/USM-181, as shown in figure 4, is a self-contained unit which can be operated from an AC source in a fixed installation or it can be operated from internal battery in a mobile situation with no access to AC power. The AN/USM-181 consists of an Oscillator, Model HP 204B, AC Voltmeter, Model HP 403B, and a Patch Panel, Model HP 353A. It is intended for measurement of transmission line and system characteristics, such as attenuation, frequency response, signal losses and gains. All three instruments are housed in an aluminum case and response, are removable for servicing or for individual use. A common power supply serves both the oscillator and the voltmeter. The patch panel requires no power for its operation.

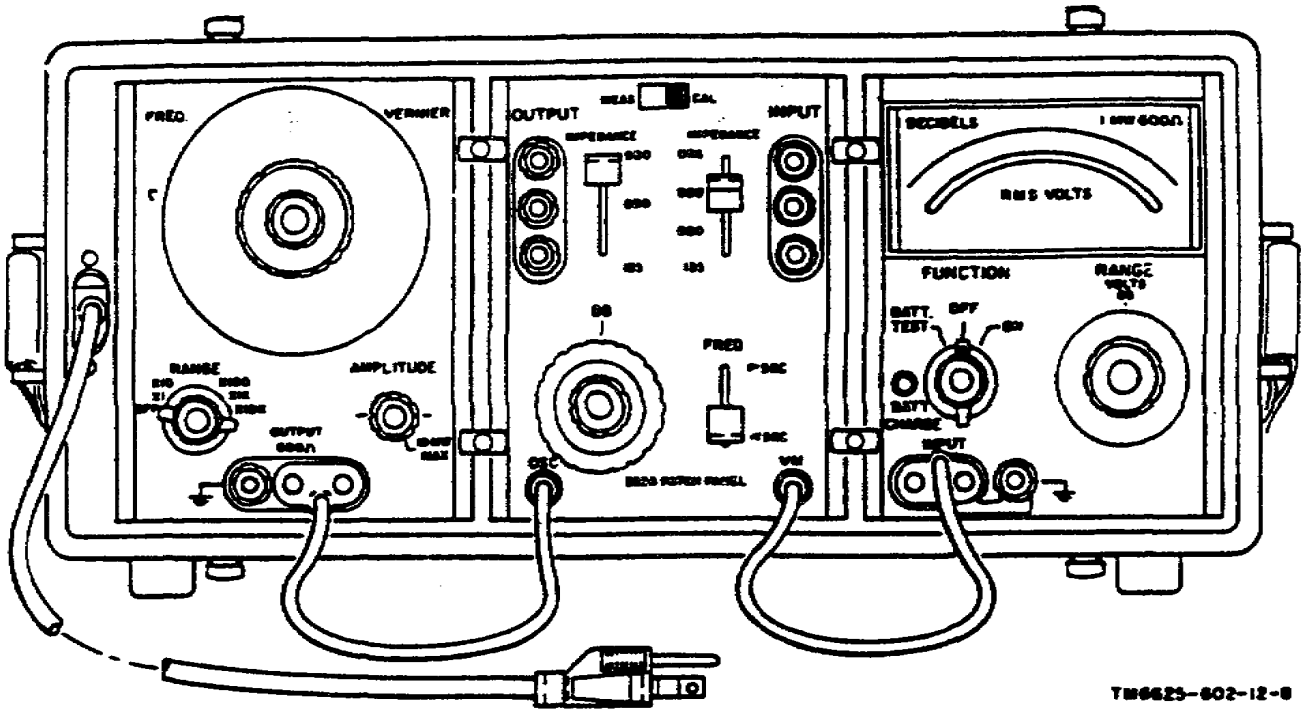


Figure 4. Telephone Test Set AN/USM-181.

a. Oscillator, Model BP 204B. This Variable-Frequency Oscillator (VFO) is capable of supplying a practically distortion-free sine-wave test signal within the frequency limits of 5 to 560 kHz in five ranges. The vernier tuning gives a dial reading accuracy of ± 3 percent. Output power is adjustable to a maximum of 10 dBm into a 600-ohm load. Output amplitude remains practically constant throughout the entire frequency range. Power is furnished by four internal rechargeable batteries, with recharge capability from the 115/230-volt supply.

b. Voltmeter, Model HP 403B. This voltmeter is capable of measuring from 0.001 to 300 volts Root Mean Square (RMS), or signal levels from -72 to +52 dB above 1 milliwatt (dBm) when terminated in 600 ohms over a frequency range of 5 Hz to 2 megahertz (MHz). Input impedance is 2 megohms, high enough to allow bridging across circuits without loading. The voltmeter circuit is protected from excessively strong input signals by a 1/16-amper instrument fuse. Power is furnished by rechargeable batteries enclosed within the case.

c. Patch Panel, Model BP 353A. This patching panel contains a precision attenuator to insert 110 dB loss in 1 dB steps. The output of the attenuator is connected through an impedance-matching transformer to the external circuits. The patching panel provides a 600 ohm load for the voltmeter, enabling measurements in dBm as well as in corresponding volt RMS. Further, it provides facilities for matching impedances among oscillator, voltmeter, and line. The patching panel is a passive unit; it contains no amplifier. A frequency switch arranges the circuit to respond to the oscillator in two ranges: 50 Hz to 5 kHz, and 5 kHz to 56 kHz.

Learning Event 6: NOISE-LEVEL-VU MEASURING SET, MODEL TTS-37B.

The TTS-37B shown in figure 5 is designed to measure noise and signal levels, including speech. It is a receptive device only; it does NOT furnish a test signal.

a. Meter scale. The meter has two scales. The first scale (VU-DB) reads level either in volume units (VU) or tone levels (dBm) of signals. The second scale (dBrn) reads on very small signal levels because it indicates noise. There is an offset of 10 dB between zero references of the two meter scales.

b. Jacks. One monitor jack (MON DC) 6 provides a DC output which may be used to drive a recorder. A second monitor jack (MON AC) 5 provides an AC output which may be used to drive an impulse noise-measuring set, a telephone headset, or an adjustable low-noise, high-gain amplifier.

c. Weighting. A switchable filter network provide C-message weighting and two band weightings.

(1) C-message. The C-message weighting filter section passes frequencies between 0.7 and 2.5 kHz.

(2) High-pass. A filter section, called high-pass, is essentially a bandpass filter that passes frequencies between 0.5 and 10 kHz.

(3) Low-pass. Two low-pass filter sections give a choice of band weighting from 0 to 3 kHz or 0 to 15 kHz respectively.

d. Dialing. Provisions are also made for dialing out, talking over the circuit under test, and for holding the circuit.

e. Sensitivity. Sensitivity of the instrument extends from absolute values of -95 to +23 dBm. Two attenuators are provided for varying the input signal level in 1 and 10 dB steps, respectively. Both attenuators are calibrated in two scales: dBm and dBrn. An input noise level that requires an attenuator setting of +80 dBrn under C-message weighting in order to show 0 dBm on the meter is equivalent to an input level of +80 dBrnc0 to the attenuator. Further, there is a 10 dB difference between meter scales for dBm and dBrn. In actual input level values, 0 dBm is therefore equal to +90 dBrnc0 with C-message weighting, and 0 dBrnc0 is equal to -90 dbm.

f. The function of the indicators, controls and connectors/jacks for the TTS-37B are listed and explained in table 1 of the appendix.

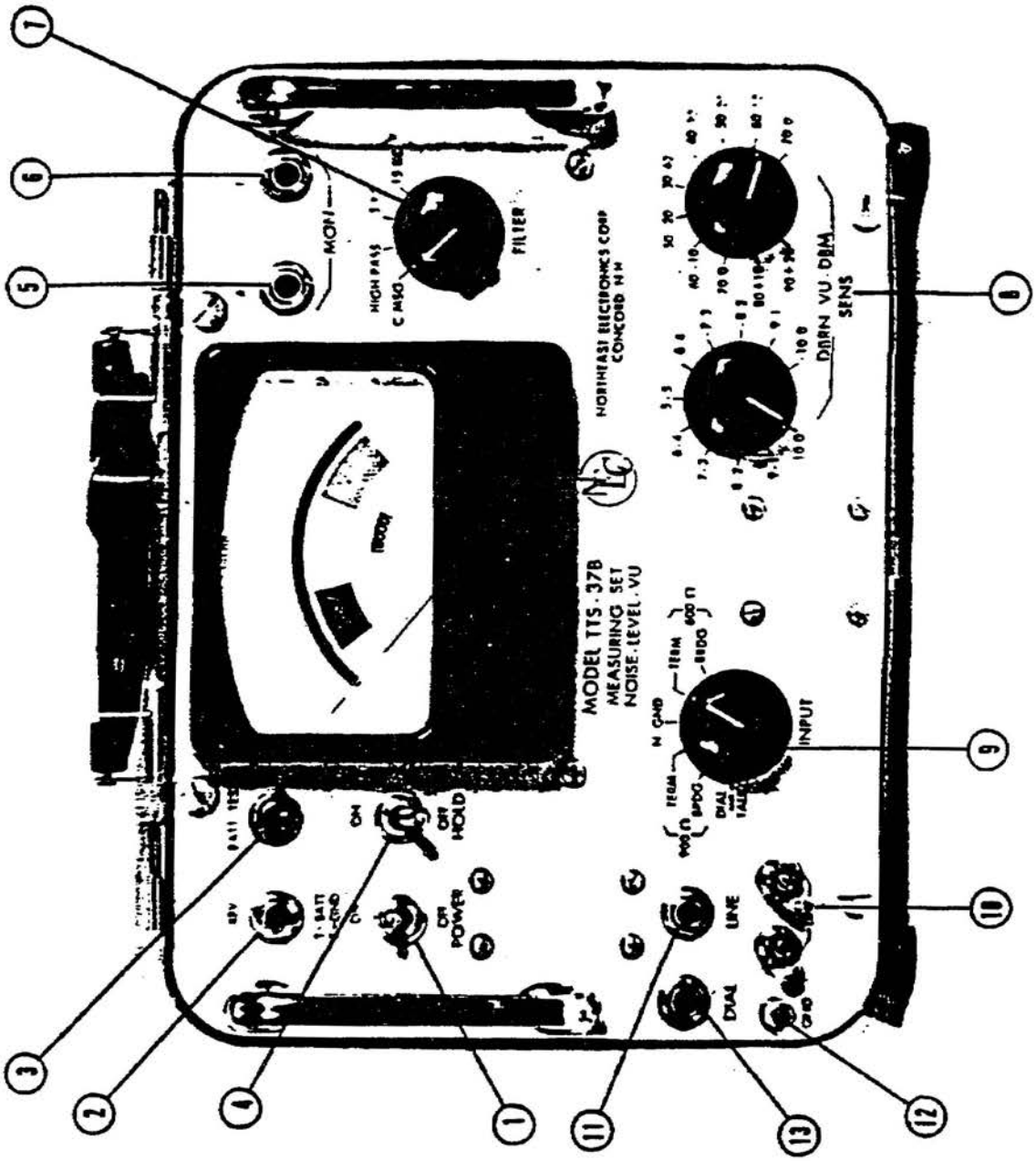


Figure 5. Measuring set noise-level-VU, Model TTS-37B and TTS-37BR

Learning Event 7: TEKTRONIX OSCILLOSCOPE AN/USM-281C.

The Oscilloscope 281C, shown in figure 6, is designed for general purpose wave form measurements using a single or dual-trace display with normal or delay sweep. It consists of Oscilloscope OS-245(P) /U (main frame); two vertical amplifier plug-in units, AM-6565/U; and Dual Time Base Plug-In Unit TC-1085/U.

a. Main frame. The main frame contains the display (Cathode Ray Tube (CRT)), power supply components and three compartments for provisions to plug in the two vertical amplifiers and time base units. The main frame compartments are compatible with other plug-in units which are not supplied with the oscilloscope.

b. Vertical amplifier. The vertical amplifiers are wideband amplifiers (DC to 50 MHz) that provides vertical deflection signals to the mainframe vertical amplifier circuits. Constant bandwidth is provided over all of the deflection factor settings with each setting selectable for either calibrated or uncalibrated operation. Display polarity is also selectable, as is the magnification factor. Use of two vertical amplifier compartments in the main frame allows one amplifier to be used alone for single-trace operation or two amplifiers to be used for dual-trace operation. The vertical amplifier can also be used in the mainframe horizontal axis compartment for calibrated X-Y display purposes.

c. Dual time base. The dual time base unit provides horizontal deflection signals to the main frame CRT circuits for Normal, Intensified Delaying, Delayed and Amplifier modes. Either calibrated or uncalibrated operation may be selected in any mode. In normal sweep mode, only the main sweep operates. In intensified delaying sweep mode, the main sweep is intensified only during the periods set for the delayed sweep with the position of the intensified portion adjustable to any point of the main sweep. In delayed sweep mode, the intensified portion of the main sweep is displayed over the full 10 centimeters (CRT) of the graticule area. In amplifier mode, the horizontal amplifier can be used for X-Y displays or for an externally applied sweep signal.

d. The description of the controls, indicators, and connectors for this oscilloscope are explained in table 7 of the annex.

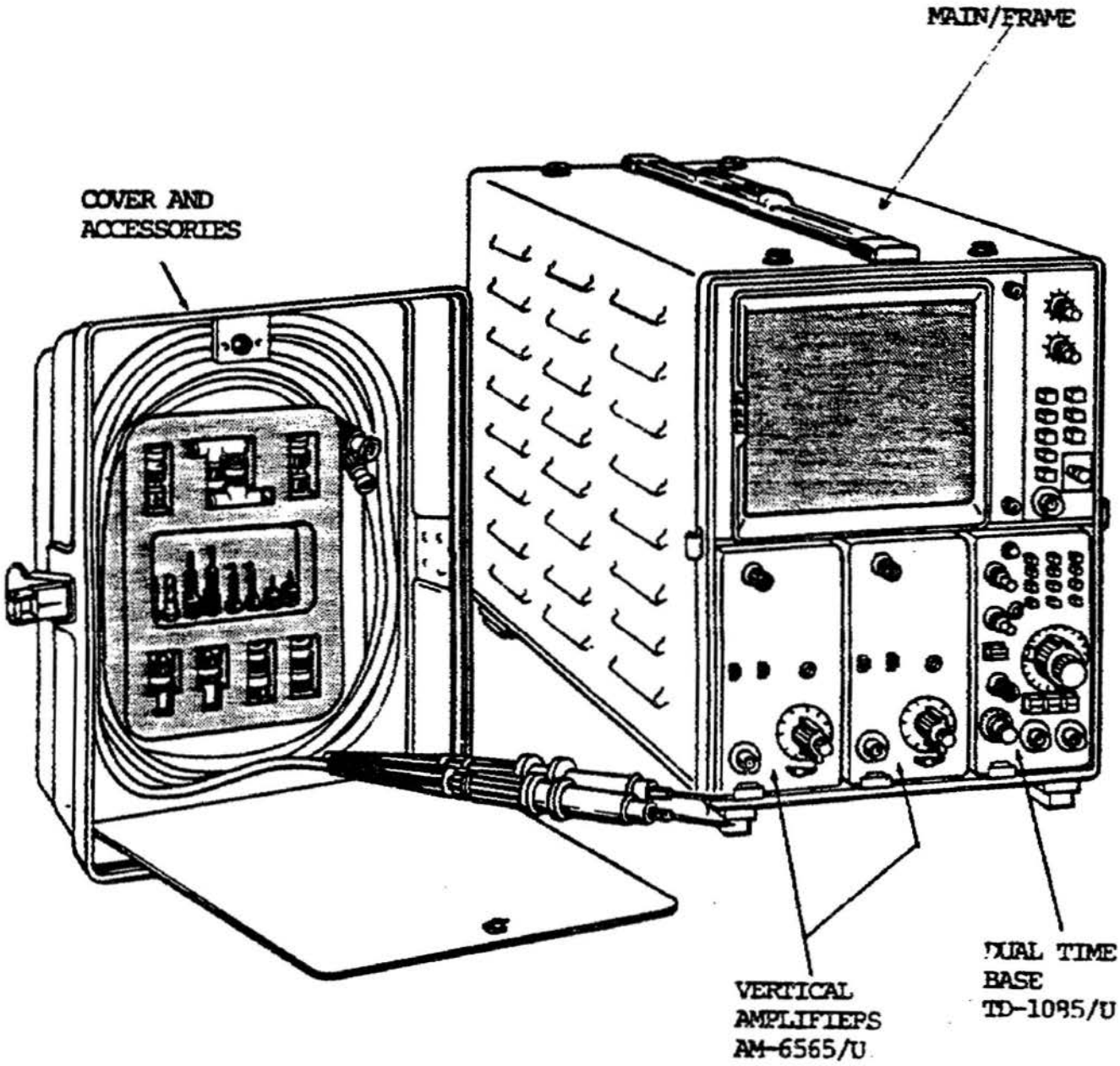


Figure 6. Oscilloscope, AN/USM-281C.

Learning Event 8: DELAY EQUALIZER GROUP, OA-880/FTC (UE-5).

The delay equalizer shown in figure 7 is used to provide compensation for envelope delay distortion in voice-frequency lines or telephone carrier channels.

a. Each of the six equalizer modules, contain two delay sections for a total of 12 delay sections. Each of the 12 equalizer sections are designed to select a small portion of the received signal spectrum and to adjust that portion to phase distortion requirements.. You as a circuit conditioner may be required to adjust all 12 sections of the equalizer or you may only have to adjust 1 or 2 sections to meet the phase distortion requirements. After equalization has been completed, the equalizer is left on line and becomes part of the line conditioning equipment. It is not to be disturbed by anyone except authorized personnel.

b. Each of the delay equalizer section has a delay and a gain control that functions in conjunction with the low (LO), high (HI) and OUT function switch. The first delay module has a SIGNAL GAIN control that adjusts the overall signal level, where the GAIN control of each delay section only adjusts the gain for that specific frequency spectrum. When the LO, HI, OUT function switch of a delay section is placed in the OUT position, the VF signal bypasses that delay section and is applied to the next delay section. For example, the first delay section of the equalizer is the 600 Hz section. When the function switch is in the OUT position the VF signal bypasses the 600 Hz section and is applied directly to the 800 Hz section (second section). When the function switch is in the HI position, maximum delay is introduced and when it is in the LO position a smaller amount of delay is introduced to the VF signal. The 600 Hz delay control permits adjustment of the amount of delay within the HI and LO ranges.

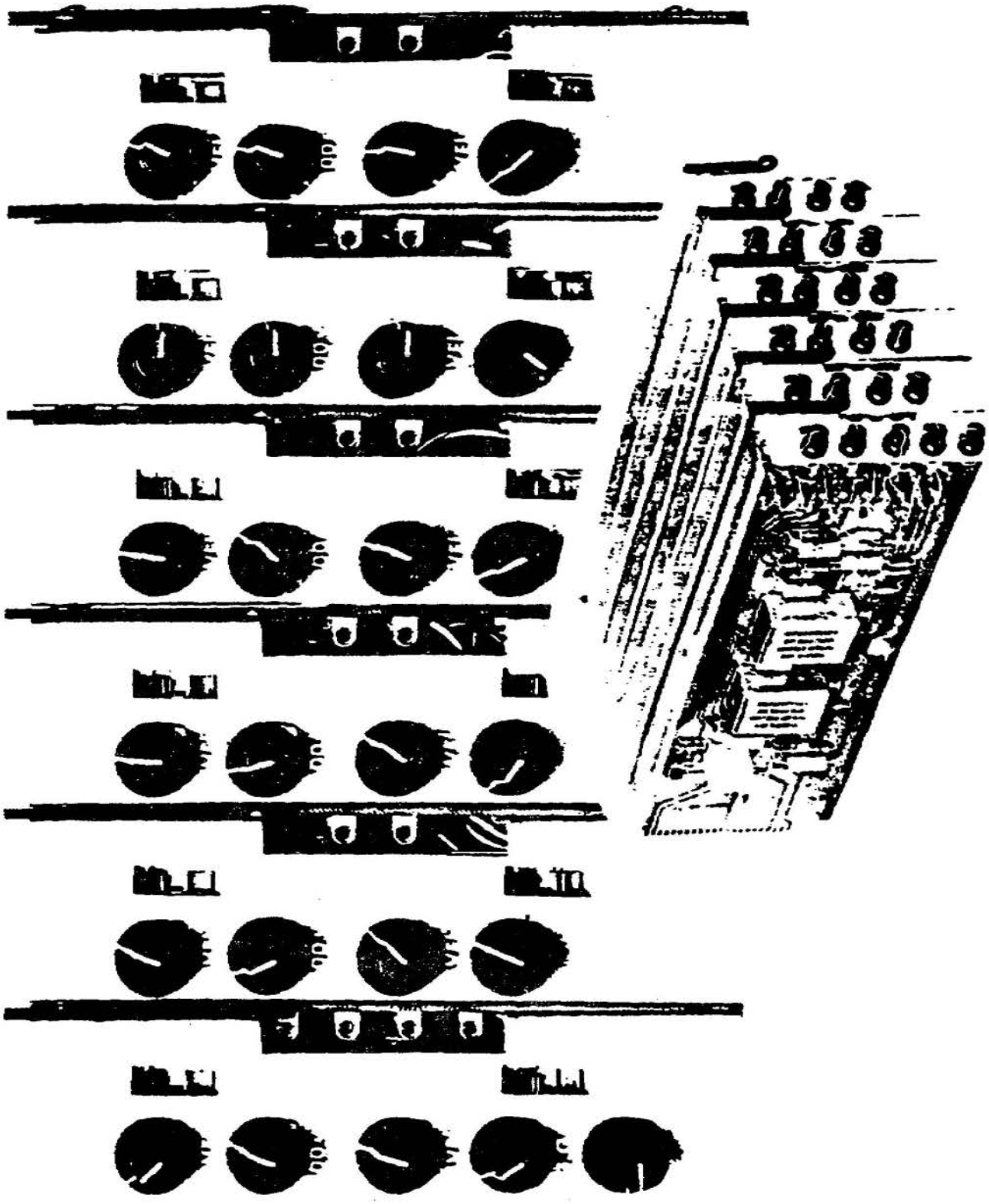


Figure 7. Delay equalizer group, OA-880/FTC (UE-5)

LESSON 3
PRACTICE EXERCISE

In each of the following exercises, select the ONE answer that BEST completes the statement or answers the question. Indicate your answer by circling the correct letter in your subcourse booklet.

1. In a technical control center, a variety of test equipment items are used by technical controllers and circuit conditioners. In addition to generalized test equipment, a circuit conditioner uses specialized equipment, such as

a. X-Y recorders, spectrum analyzers, envelope-delay test, and oscilloscopes.

b. wave analyzers, X-Y recorders, spectrum analyzers, and envelope-delay sets.

c. spectrum analyzers, envelope-delay sets, oscilloscopes, and VF signal generators.

d. envelope-delay sets, oscilloscopes, VF signal generators, and decibel meters.

2. Assume that you are recommending the purchase of "off-the-shelf" test items to use in circuit conditioning. Your primary considerations will be the

a. operational reliability and size.

b. mounting arrangements and placement of controls.

c. power input requirements and mounting arrangements.

d. operational reliability and ability to measure circuit parameters.

3. The Transmission Impairment Measuring Set (TIMS) consists of two main sections, which are

a. the envelope delay and frequency response section.

b. the setup controls section and digital display section.

c. the transmit section and receive section.

d. digital display section and transmit section.

4. The principle corrective device used to condition VF communication circuits is an equalizer. For maximum benefit in use of circuits that may be required to carry data and secure voice signals, the device should be capable of

a. correcting amplitude versus frequency distortion as well as maximum net loss variation.

b. correcting amplitude versus-frequency distortion.

c. correcting envelope delay as well as amplitude-frequency distortion.

d. correcting for harmonic distortion.

5. There are approximately 16 different parameter tests that may be performed using the TIMS, however one specific test is optional and must be requested when ordering the test set. The test that must be requested is the

a. nonlinear distortion test.

b. peak-to-average ratio test.

c. noise-to-ground test.

d. single tone interference test.

6. Telephone Test Set AN/USM-181 consists of an oscillator, a voltmeter, and a patching panel. The function of this test set is to measure a circuit to determine its

a. attenuation, envelope delay, and gain.

b. gain, frequency response, and attenuation.

c. envelope delay, gain, and frequency response.

d. frequency response, attenuation, and envelope delay.

7. Noise-Level-VU Measuring Set Model TTS-37B can be used for several functions. One function it CANNOT perform is

a. provide a DC output to drive a recorder.

b. determine signal level in dBm.

c. measure noise level in dBrn.

d. furnish a test tone.

8. The meter used with Noise-Level-VU Measuring Set Model TTS-37B has a scale marked VU-DB. The purpose of this scale is to indicate voice peaks in

a. dBm and tone levels in VU.

b. dBm and tone levels in dB.

c. volume units and tone levels in dB.

d. volume units and tone levels in dBm.

9. The meter scales of Noise-Level-VU Measuring Set Model TTS-37B are offset 10 dB. If the meter measures a level of +5 dBm on the VU-DB scale, it should read a level on the dBrn scale of

a. +95.

b. -95.

c. +85.

d. -85.

10. The Oscilloscope AN/USM-281C has two vertical wideband amplifiers that provides vertical deflection signals to the mainframe vertical amplifier circuit. The vertical amplifiers may also be used

a. for matching input impedance, image brightness and to control the sweep rate.

b. to provide continuously variable calibrated or uncalibrated deflection to the mainframe vertical amplifier.

c. In the mainframe horizontal axis compartment for calibrated X-Y display purpose.

d. In the amplifier mode to insert an externally applied sweep signal.

11. Delay Equalizer Group, OA-880/FTC is always installed at the receiving end of a communication circuit. One feature of its design is that it contains

a. 12 equalizer sections that select a small portion of the receive signal spectrum for delay distortion compensation.

b. sweep circuits that automatically sample 12 small portions of the received signal spectrum for amplitude compensation.

c. 12 individual amplifiers to compensate for loss through each selected portion of the received signal.

d. 12 removable sections that are installed at the time of equalization to equalize that portion of the receive signal in question.

12. The main function of the SENS controls of Noise-Level-VU Measuring Set TTS-37B is to

a. select the function of the input circuits.

b. connect a telephone head set to monitor the tone being measured.

c. adjust the amount of gain necessary in the set to obtain a meter reading.

d. select the desired filter(s) to be used when measuring the test signal.

13. The VU quality scale of the Noise-Level-VU Measuring Set, Model TTS-37B is marked in three colors which are

a. green from 0 to 10, yellow from -6 to 0 and red from -15 to +6 dB.

b. green from 0 to +3, yellow from -6 to 0 and red from -15 to -6 dB.

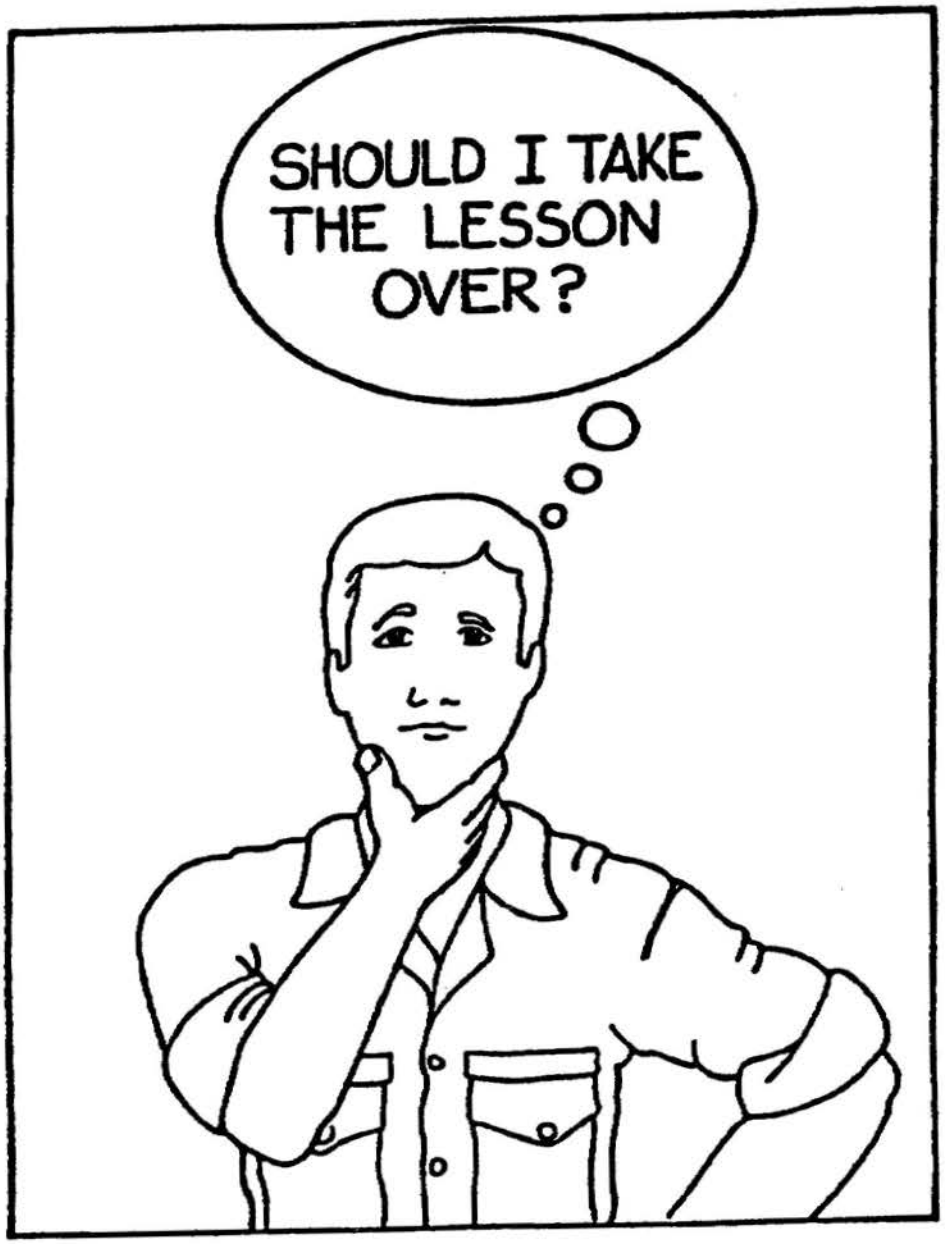
c. blue from 0 to +3, yellow from -6 to 0 and red from -15 to -6 dB.

d. red from 0 to +3, yellow from -6 to 0 and blue from -15 to -6 dB.

Check your answers with Lesson 3: Practice Exercise Solution Sheet (page 104) and make necessary corrections.

A REMINDER

You will need the text materials to complete the examination of this subcourse. Therefore, keep all tests until the school notifies you that you have successfully completed the subcourse.


SHOULD I TAKE THE LESSON OVER?

TM EXTRACT

LESSON 2

DCAC 300-175-9

TABLE 1. DCS TECHNICAL SCHEDULES FOR GOVERNMENT-OWNED CIRCUITS

ITEM NUMBER	DESCRIPTION OF DCS SERVICE
	Technical Schedules pertinent to services not mentioned herein will be developed on a case-by-case basis as requests for these services are received by the responsible DCA Circuit Allocation and Engineering Organization. When warranted by the degree of usage, an appropriate Technical Schedule for the particular service will be published by DCA.
	CATEGORY 1: USER-TO-USER CIRCUITS
	VOICE
1A	Nonsecure voice circuit.
1B	Secure voice, operating at 2400 baud.
1C	Secure voice, operating at 50,000 b/s. This is a special schedule pertaining to transmission over metallic facilities without regenerators.
1D	Secure voice, operating at 50,000 b/s. This is a special schedule pertaining to long-distance transmission over radio systems.
1E	Alternate voice/record, including secure S1 voice or data, operating at rates from 2400 b/s up to 9600 b/s. Circuit parameter code S3 is not available for user-to-user service but was developed to permit interconnection of up to five tandem S3 links and obtain S1 circuit performance on an end-to-end basis.
	FACSIMILE
IF	Facsimile transmission that can be accommodated over a voice grade channel with no special conditioning. If the required facsimile (including telephoto) service involves special conditioning of the channel, specific circuit parameters will be based on transmission means, circuit length, and characteristics of the equipment used to terminate the circuits.

Enclosure 1

TABLE 1. DCS TECHNICAL SCHEDULES FOR GOVERNMENT-OWNED CIRCUITS (CON.)

ITEM NUMBER	DESCRIPTION OF DCS SERVICE
	CATEGORY 1: USER-TO-USER CIRCUITS (CON.)
	TELEGRAPH AND DATA
1G	Less than 46 baud. Includes 60 wpm teletypewriter and other d.c. keying service.
1H	46 through 75 baud. Includes 75 wpm and 100 wpm teletypewriter and other d.c. keying service.
1J	76 through 150 baud. Includes 110 baud teletypewriter and other d.c. keying service.
1K	Less than 46 baud. Used where d.c. keying is converted to tone on a single channel basis.
1L	46 through 75 baud. Used where d.c. keying is converted to tone on a single channel basis.
1M	76 through 150 baud. Used where d.c. keying is converted to tone on a single channel basis.
1N	066-068 IBM transceivers (10 to 40 cpm).
1P	300 through 600 baud. Includes data card or other service.
1Q	1200 baud. Includes data card or other service.
1R	2400 b/s; alternate voice/record service.
1S	4800 b/s; alternate voice/record service.
1T	9600 and 7200 b/s; alternate voice record service.
1U	1200 to 16000 b/s when using data modems containing adaptive equalizers.

Enclosure 1

TABLE 1. DCS TECHNICAL SCHEDULES FOR GOVERNMENT-OWNED CIRCUITS (CON.)

ITEM NUMBER	DESCRIPTION OF DCS SERVICE
	CATEGORY 2: VOICE FREQUENCY
	CARRIER TELEGRAPH (VFCT) SYSTEMS
2A	VFCT
	CATEGORY 3: AUTOVON ACCESS LINES
3A	Voice grade.
3B	Special grade, alternate voice/record access from AUTODIN switch, and 2400 through 9600 b/s secure voice access from secure voice terminals, cordboard (SECORD), SEVAC, and other secure four-wire switchboards.
3C	Special grade, alternate voice/record.
	CATEGORY 4: AUTOVON TRUNKS
4A	Interswitch voice grade.
4B	Interswitch special grade, not transoceanic (no regenerators at either end).
4C	Interswitch special grade, not transoceanic (regenerators at both ends).
4D	Interswitch special grade, not transoceanic (regenerators at one end).
4E	Interswitch special grade, alternate voice/record.
4F	Loop-around, regenerative, Option 1. Regenerators located physically at the AUTOVON Switching Center.
4G	Loop-around, regenerative, Option 2. Regenerators located physically at a remote site on Government property.

Enclosure 1

TABLE 1. DCS TECHNICAL SCHEDULES FOR GOVERNMENT-OWNED CIRCUITS (CON.)

ITEM NUMBER	DESCRIPTION OF DCS SERVICE
	CATEGORY 5: AUTODIN ACCESS LINES
5A	75 baud; d.c. keying.
5B	150 baud; d.c. keying.
5C	75 baud; from terminal to switch or to a bridge at a transmission nodal point, tone keying.
5D	150 baud; from terminal to switch or to a bridge at a transmission nodal point, tone keying.
5E	300 baud; from terminal to switch or to a bridge at a transmission nodal point, tone keying.
5F	600 baud; from terminal to switch or to a bridge at a transmission nodal point, tone keying.
5G	1200 baud; limited to data service only.
5H	1200 b/s multiplexed; from a user or transmission nodal point where a VF channel is multiplexed or bridged with any compatible combination of 75-, 150-, 300-, or 600-baud modems not to exceed 1200 b/s total. VF bridging is used at transmission nodal points to serve noncollocated users.
5I	Not used.
5J	2400 b/s; alternate voice record service.
5K	Not used.
5L	Not used.
5M	4800 b/s; alternate voice/record service.
5N	Not used.

Enclosure 1

TABLE 1. DCS TECHNICAL SCHEDULES FOR GOVERNMENT-OWNED CIRCUITS (CON.)

ITEM NUMBER	DESCRIPTION OF DCS SERVICE
	CATEGORY 5: AUTODIN ACCESS LINES (CON.)
5O	Not used.
5P	Not used.
5Q	9600 and 7200 b/s; alternate voice record data service.
	CATEGORY 6: AUTODIN INTERSWITCH TRUNKS
6A	2400 b/s through 4800 b/s; dedicated circuit from one AUTODIN switch to another.
6B	Not used.
6C	9600 and 7200 b/s; alternate voice/record service.
	CATEGORY 7: AUTOSEVOCOM ACCESS LINES
7A	Not used.
7B	Secure voice terminal, 2400 b/s, to four-wire JOSS or AUTOVON switch.
7C	Secure voice terminal, 50 kb/s baseband, to SECORD or AUTOSEVOCOM switching facility without regenerators over metallic facilities.
7D	Secure voice terminal, 50 kb/s baseband, to special 758 switch or cordboard (SECORD) or AN/FTC-31 over long-distance carrier facilities.
7E	Secure voice terminal, 50 k/s baseband to AN/FTC-31, over metallic facilities.
7F	Secure voice terminal, operating at 9600 b/s to JOSS or AUTOVON switch.

TABLE 1. DCS TECHNICAL SCHEDULES FOR GOVERNMENT-OWNED CIRCUITS (CON.)

ITEM NUMBER	DESCRIPTION OF DCS SERVICE
	CATEGORY 8: AUTOSEVOCOM TRUNKS
8A	50 kb/s baseband, over metallic facilities without regenerators.
8B	50 Kb/s baseband, over long-distance carrier facilities.
8C	Not used.
8D	2400 b/s (JOSS to either a JOSS or a cordboard) (SECORD).
8E	2400 b/s (SEVAC to JOSS or 5-D switchboard).
8F	Interswitch trunk operating at 2400 or 9600 b/s providing secure voice service. (This service is derived from the AUTOVON.)
	CATEGORY 9: 60-108 kHz BASIC GROUPS
9A	Unconditioned Wideband Service. This item normally supports user-supplied FDM 60-108 kHz group level equipment.
9B	Conditioned Wideband Service. This item normally supports a 50 kb/s requirement through the DCS by use of special GFE modem and GFE auxiliary set, such as the WECO type 303 data modem and WECO type 842 data auxiliary set which provides interconnection of subscribers on a 4-kHz basis whenever the 50 kb/s signal is removed from the user's 4-wire line. The derived service is similar to item 7D. The AN/USC-26 group data modem also may be used in deriving this service, but in the half group mode of operation the data signal level (Circuit Parameter Code X2, item k, table 2) should be reduced to -8 dBm0.
	CATEGORY 10: DIGITAL SERVICES (See Enclosure 8.)

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TABLE 2. DCS TECHNICAL SCHEDULES FOR GOVERNMENT-OWNED CIRCUITS (CIRCUIT PARAMETERS) (CON.)

CHARACTERISTICS	UNIT OF MEASURE	HP	S0	S1	S2	S3	V1	V2	D1	D2	N (1-3)
d. Maximum Change[3] In Audio Frequency	Hz		±5	±5	±5	±5	±5	±5	±5	±5	
e. Longitudinal Balance (Minimum)	dB		40	40	40	40	40	40	40	40	
f. Total Peak Telegraph Distortion (Maximum)	%										20
g. Bias Distortion (Maximum Mark or Space)	%										8
h. Idle Circuit[4] Noise (Maximum Allowable)	dBrnC0										
km mi											
0-81 (0-50)			31	31	31	31	31	31	31	31	
81-161 (50-100)			34	34	34	34	34	34	34	34	
161-644 (100-400)			37	37	37	37	37	37	37	37	
644-1609 (400-1000)			41	41	41	41	41	41	41	41	
1609-2414 (1000-1500)			43	43	43	43	43	43	43	43	
2414-4024 (1500-2500)			45	45	45	45	45	45	45	45	
4024-6438 (2500-4000)			47	47	47	47	47	47	47	47	
6438-12874 (4000-8000)			50	50	50	50	50	50	50	50	
12874-25748 (8000-16000)			53	53	53	53	53	53	53	53	
i. Single Tone Interference Below Circuit Noise In Each Mileage Category (Maximum)	dB		3	3	3	3	3	3	3	3	
j. Impulse Noise[5] (Reference Level 65 dBrnC0; Measure with Tone	Counts above reference level (maximum in 15) minutes		15	15	15	15			15	15	

[3]This measurement is not required on circuits traversing only PCM systems.
[4]Consider a satellite channel as equivalent to a 3219 kilometer (2000-mile) landline channel in determining circuit length.
[5]Reference level 60 dBrnC0 for circuits traversing PCM systems only. Measurement made with previously sampled PCM channel loaded with 2604 Hz + 5 dBm0 tone. Includes gain and phase hits lasting less than 4 milliseconds.

TABLE 2. DCS TECHNICAL SCHEDULES FOR GOVERNMENT-OWNED CIRCUITS (CIRCUIT PARAMETERS)

This table specifies circuit parameters which correspond to the various types of DCS VF services specified in table 1 except for parameters SO and HP. SO is an optional parameter that the circuit engineer may substitute in lieu of the normally specified parameter whenever the circuit is to be terminated with modems employing adaptive equalizers. SO is normally obtained without special equalization equipment being introduced into the circuit. HP is also an optional parameter that the circuit engineer may substitute in lieu of the normally specified parameter whenever the circuit is to be terminated with modems employing multilevel modulation techniques that require above-average signal-to-noise and linearity characteristics. Provision of the HP parameters normally requires special routing of the circuit over "hand selected" transmission channels.

CHARACTERISTICS	UNIT OF MEASURE	HP	SO	S1	S2	S3	V1	V2	D1	D2	N (1-3
a. Frequency Response[1]	dB										
KHz											
0.3-2.7										-2 to +6	
0.3-3.0			-3 to +12	-2 to +6	-1.5 to +4.5	-1 to +3		-3 to +8	-2 to +6	-3 to +12	
0.4-2.8							-8 to +20				
0.5-2.5			-2 to +8								
0.5-2.8				-1 to +3	-0.5 to +2	-0.5 to +1.5			-1 to +3		
0.6-2.4							-7 to +12				
1.0-2.4										-1 to +3	
0.7-2.3								-1 to +3			
b. Maximum Envelope[2] Delay Variation Allowable in Each Specified Band	micro-second										
KHz											
0.5-2.8				3000	1500	600			3000		
0.6-2.6				1500	750	300			1500		
0.8-2.6			1750							1750	
1.0-2.4										1000	
1.0-2.6				500	250	100			500		
c. Maximum Net Loss Variation (with respect to time)	dB		±4	±4	±3	±2	±4	±2	±4	±4	

[1]Loss frequency characteristics are given in terms of comparison to the measured loss at 1004 Hz. For example, in the S1 schedule, the loss frequency characteristic should not exceed the range of 2 dB less loss (-) to 6 dB more loss (+) between 0.3-3.0 KHz when compared to the measured loss at 1004 Hz. This frequency is used to avoid subharmonics of the 8 KHz frequency used extensively in PCM/TDM systems. Caution: Circuits equipped with CY-104 ( ) PCM equipment may not meet the above parameters without external equalization.

[2]Caution: Circuits equipped with CY-104 ( ) PCM equipment may not meet this parameter without external equalization.

TABLE 2. DCS TECHNICAL SCHEDULES FOR GOVERNMENT-OWNED CIRCUITS (CIRCUIT PARAMETERS) (CON.)

CHARACTERISTICS	UNIT OF MEASURE	HP	S0	S1	S2	S3	V1	V2	D1	D2	M (1-3)
k. Terminal Impedance (600 ohms)	% Tolerance		±10	±10	±10	±10	±10	±10	±10	±10	
l. Data Transmission Level (Composite)	dBm0		-13	-13	-13	-13	-13	-13	-13	-13	
m. Phase Jitter[6] (Maximum Peak-to-Peak)	Degrees		10	10	10	10			10	10	
n. Harmonic[7] Distortion	dBm0		-40	-40	-40	-40	-40	-40	-40	-40	
o. Gain Hits[8] (>4 msec) Gain Change >3 dB or >4 dB	Counts (Maximum) in 15 minutes		8 6	8 6	8 6	8 6			8 6	8 6	
p. Phase Hits[9] (>20 degrees and >4 msec.	Counts (Maximum in 15 minutes exceeding threshold)		8	8	8	8			8	8	
q. Dropouts (>12 dB and >10 msec)	Dropouts (Maximum in 15 minutes)		2	2	2	2			2	2	

[6]Not required for circuits traversing PCM systems only.

[7]This parameter is obsolete and has been replaced by parameter s. A 704 Hz test tone at -10 dBm0 is used.

[8]Gain hits are sudden changes in the gain or loss of a circuit. Measurement made at circuit activation and as necessary as a troubleshooting aid.

[9]Phase hits are sudden changes in phase of the transmitted signal caused by the transmission path. Measurement made at circuit activation and as a troubleshooting aid.

TABLE 2. DCS TECHNICAL SCHEDULES FOR GOVERNMENT-OWNED CIRCUITS (CIRCUIT PARAMETERS) (CON.)

CHARACTERISTICS	UNIT OF MEASURE	HP	SO	S1	S2	S3	V1	V2	D1	D2	N (1-3)
r. Signal to C-Notched Noise Ratio[10]	dB	28	24	24	24	24	24	24	24	24	
s. Nonlinear Distortion (Using 4-tone method)[11]											
(1) Signal to Second Order Distortion	dB	35	25	25	25	25	25	25	25	25	
(2) Signal to Third Order Distortion	dB	40	30	30	30	30	30	30	30	30	

The Technical Schedule portion of this table concludes with characteristic s, above. The characteristics following are provided as a troubleshooting aid and may be used on an optional basis. They are intended to assist the technician in clearing troubles on circuits traversing PCM systems, which are not revealed by the characteristics specified above. Characteristic w will be experienced mainly on PCM equipments which employ a single coder-decoder for all channels. Loading of channels as specified for characteristic w may involve channels not accessible to the end point circuit tester. Characteristic x is useful in identifying high-level transient signals on circuits which elude measurements made with conventional level measuring equipment and thus also may be useful in measuring signals that traverse FDM systems.

t. Gain Linearity at Input Levels of: dBmO	dB										
0 to -37			±0.5	±0.5	±0.5	±0.5	±0.5	±0.5	±0.5	±0.5	±0.5
-37 to -50			±1.0	±1.0	±1.0	±1.0	±1.0	±1.0	±1.0	±1.0	±1.0
-50 to -54			±3.0	±3.0	±3.0	±3.0	±3.0	±3.0	±3.0	±3.0	±3.0

[10] Measurement is made with 1004 Hz -10 dBmO holding tone. Both idle circuit noise and C-notched noise are to be measured on all circuits except as noted otherwise. Optional measurement on circuits traversing noncompandored FDM facilities. Required measurement on circuits traversing compandored facilities, such as all-PCM systems and analog compandored FDM systems (e.g. type N carrier).

[11] Nonlinear distortion measured using the four-tone test method is the standard method of measurement of distortion in the DCS. The obsolete harmonic distortion parameter has been retained in this table for use by those stations not yet equipped with transmission impairment measurement sets.

TABLE 2. DCS TECHNICAL SCHEDULES FOR GOVERNMENT-OWNED CIRCUITS (CIRCUIT PARAMETERS) (CON.)

CHARACTERISTICS	UNIT OF MEASURE	HF	S0	S1	S2	S3	V1	V2	D1	D2	N (1-3)
u. Signal to Quantizing Distortion at Input Levels of: dBm0	dB										
0 to -30			33	33	33	33	33	33	33	33	
-30 to -40			27	27	27	27	27	27	27	27	
-40 to -45			22	22	22	22	22	22	22	22	
v. Circuit[12] Continuity (Dropouts >10 dB and >250 msecs)	Dropouts (Maximum in 24 hrs)		10	10	10	10	10	10	10	10	
w. Cross-Modulation[13] (from adjacent circuits) Maximum Notched Impulse Noise Threshold	dBrn0		57	57	57	57	57	57	57	57	
x. Maximum[14] Operating Signal Level (Peak) Reference Threshold 95 dBrn0 Flat wtg	Counts above reference threshold (Maximum in 15 minutes)		15	15	15	15	15	15	15	15	

[12]This measurement may be made on circuits where loss of synchronization of the high bit rate digital trunk is suspected. Statistics are normally measured using a 1004 Hz -10 dBm0 tone on the circuit and a strip chart recorder to record the dropouts.

[13]This measurement may be made on circuits wherever cross-modulation is suspected. Measurement made with previously scanned channel and measured circuit activated with 1004 Hz tone at a level of -10 dBm0.

[14]This measurement is made with an impulse noise measuring set bridged across the circuit during periods of maximum signal activity. The measurement indicates the presence of high-level transient signals which cause intermodulation distortion, cross-talk and cross-modulation of adjacent channels. It is noted that 95 dBrn0 equates to a level of +5 dBm0.

TABLE 3. DCS TECHNICAL SCHEDULES FOR GOVERNMENT-OWNED CIRCUITS
GROUP BANDWIDTH CIRCUITS - FDM OR DATA DERIVED

CHARACTERISTICS	UNIT OF MEAS	X1	X2
a. Frequency Response kHz loss with respect to 104.08 kHz	dB		
km mi			
0-100 (0-62.5)		-1.3 to +1.8	-1.3 to +1.8
100-201 (62.5-125)		-2.0 to +2.9	-2.0 to +2.9
201-402 (125-250)		-2.5 to +4.0	-2.5 to +4.0
402-804 (250-500)		-2.9 to +4.0	-2.9 to +4.0
804-1609 (500-1000)		-3.3 to +4.9	-3.3 to +4.9
1609-3218 (1000-2000)		-4.4 to +4.9	-4.4 to +5.9
3218-6436 (2000-4000)		-4.4 to +6.7	-4.4 to +6.7
b. Envelope Delay (reference 84 kHz)			
(1) Equalized parabolic curve 64-104 kHz	micro-second		
km mi			
0-100 (0-62.5)			(See footnote (1))
100-201 (62.5-125)			
201-402 (125-250)			
402-804 (250-500)			
804-1609 (500-1000)			
1609-3218 (1000-2000)			
3218-6436 (2000-4000)			
(2) Unequalized, typical points on curve.			
Measured at 60 kHz		3000	
Measured at 64 kHz		300	
Measured at 108 kHz		2800	

(1) Use values for AN/USC-26 from figure 1.

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TABLE 3. DCS TECHNICAL SCHEDULES FOR GOVERNMENT-OWNED CIRCUITS GROUP BANDWIDTH CIRCUITS - FDM OR DATA DERIVED (CON.)

CHARACTERISTICS	UNIT OF MEAS	X1	X2
c. Amplitude Stability	dB		
Short Term (30 seconds)		±.5	±.5
Long Term (30 seconds)		±1.0	±1.0
d. Maximum Frequency Offset	Hz	±2	±2
e. Impedance	ohm		
(1) Balanced (preferred)		135	135
(2) Unbalanced		75	75
f. Return Loss, minimum over frequency range 60-108 kHz	dB	25	25
g. Interface Transmission Level Point (assuming Government-furnished interconnect filters)	dBm		
Group Channel Input Level		-34.5	-5 to -42
Group Channel Output Level		-12.0	-5 to -42
h. Phase Jitter, Peak-to-Peak	degree	10	10

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TABLE 3. DCS TECHNICAL SCHEDULES FOR GOVERNMENT-OWNED CIRCUITS GROUP BANDWIDTH CIRCUITS - FDM OR DATA DERIVED (CON.)

CHARACTERISTICS	UNIT OF MEAS	X1	X2
i. Random Noise Unweighted km / mi 0-804 (0-500) 804-1609 (500-1000) 1609-3218 (1000-2000) 3218-6436 (2000-4000	dBm0	 -38 -35 -32 -29	 -38 -35 -32 -29
j. Impulse Noise, Flat Weighting 15-Minute Measurement at -10 dBm0.	Maximum Count	175	175
k. Average (30-second) Long-Term Power in 60-108 kHz band, maximum permissible.	dBm0	-5	-5(2)
l. Maximum Operating Signal Power permitted in any 4-kHz subchannel. Total number of active channels must be such that characteristic k is not violated.	dBm0	-13	-13
m. Maximum Test Tone Power Level in any 4-kHz subchannel. Test duration less. than 5 minutes Test duration more than 5 minutes.	dBm0	 -10 -15	 -10 -15

(2)For half-group operation of the AN/USC-26, -8 dBm0 applies.

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TABLE 4. DCS TECHNICAL SCHEDULES FOR GOVERNMENT-OWNED CIRCUITS
Z1, Z2, Z3 TECHNICAL SCHEDULES

(Z1 through Z3 technical schedules establish the parameters for full-duplex 50 kbps transmission media within the bandwidth of 0.1 to 50 kHz terminated in a nominal 135 ohms. The Z Schedules apply only to terminals operating in the baseband mode.

Z1 Parameters are for a local circuit used to interconnect two KY-3 terminals over physical metallic nonloaded cable pairs. The lineup loss must portray a curve with a smooth rolloff.

Z2 Parameters are for a local circuit used to interconnect a KY-3 to a switchboard over metallic facilities as in Z1. However, since the switchboard provides no equalization, all equalization on the cable pair transmitting toward the switchboard must be "equipped by the line." Note the different requirements in each direction.

Z3 Parameters are for a trunk circuit used between two switchboards where no equalization capability exists at either end. It applies also to any wireline segment of a wideband long haul trunk.)

CHARACTERISTIC	UNIT OF MEASURE	Z1 BOTH DIRECTIONS	Z2 SUB TO SWITCH	Z2 SWITCH TO SUB	Z3 BOTH DIRECTIONS
1. Low-Frequency Noise[1,2]	dBm	-36	-36	-36	-36
2. S+N/N	dB	20	24	24	24
3. Impulse Noise[3] a. Wideband	1 count per second with threshold set at stated level (dB) below the received signal level.	12	12	12	12
b. AN/FTC-31 low frequency receive	1 count per second with threshold set at stated level (dB) below 2600 Hz SF level.		6		6

See page 89 for footnotes.

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TABLE 4. DCS TECHNICAL SCHEDULES FOR GOVERNMENT-OWNED CIRCUITS
Z1, Z2, Z3 TECHNICAL SCHEDULES (CON.)

CHARACTERISTIC	UNIT OF MEASURE	Z1 BOTH DIRECTIONS	Z2 SUB TO SWITCH	Z2 SWITCH TO SUB	Z3 BOTH DIRECTIONS
4. Net Loss Variation[2,4]	dB	±2	±2	±2	±2
5. Lineup Loss (kHz)	dB loss of 0dBm transmitted tone		(5)		
a. 0.1		+13	4	+13	
1.0		+12	4	+12	
3.0		+14	4	+14	
5.5		+17	4	+17	
10.0		+20	4	+20	
18.0		+23	4	+23	
25.0		+25	4	+25	
32.0		+27		+27	
50.0		+30	6	+30	
			(5&6)	(7)	
b. .1 to 50.0			-2, +2	-2, +2	-2, +2
1.0 to 40.0			-1, +1	-1, +1	-1, +1
6. Envelope Delay	Microsec reference @ 6 kHz	See figure 2	See figure 2	See figure 2	See figure 2
7. Nominal Data Input Signal Level	volts peak-to-peak	1	1	1	1

See page 17 for footnotes.

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Footnotes to table 4:

1. In no case should absolute power level exceed -36 dBm in the VF bandwidth.

2. Reference frequency is 1 kHz at 0 dBm0.

3. The impulse noise (IPN) meter is normally configured for dBrn. After measuring the received digitized voice signal with a dB meter, use the following equation for the dBrn setting:

dBrn = 90 + signal level (measured reading) - 12 dB

Example: If the signal level is measured to be -2 dBm, then dBrn = 90 - 2 - 12 = 76 dBrn. Set reference level dBrn dials as follows:

10 dB step dial at 60.
High-level dial at 16. (60 + 16 = 76 dBrn)
Mid-level dial at 10. (60 + 10 = 70 dBrn)
Low-level dial at 4. (60 + 4 = 64 dBrn)
Use 10.2 to 51 kHz (or external wideband) filter.

4. At the time of the alinement of the wideband repeaters in the subscriber to switch direction, adjust the receive level of the 1 kHz reference frequency to 0 dBm with the entire frequency response within the stated specifications (-1 to +1 dB between 1 and 40 kHz and -2 to +2 dB between .1 to 50 kHz.) In a later check, the reference 1 kHz receive level may vary (net loss variation) up to -2 or +2 dB from the 0 dB alinement level. The entire frequency curve should be equally displaced. For example, if the 1 kHz tone is 1 dB cold (or reading -1 dB on the meter indicating a +1 dB loss), then the entire frequency response curve must now be referred to the +1 dB loss level. The frequency response curve must fall within the shifted limits of 0 to +2 dB between 1 and 40 KHz and -1 to +3 dB between .1 to 50 kHz. If the 1 KHz tone is 2 dB hot, then the frequency response curve must fall within the limits of -3 and -1 dB between 1 and 40 kHz and -4 to 0 dB between .1 and 50 kHz.

5. A 4 dB loss at 25 kHz is maximum allowable loss. Loss from 0.1 to 18.0 kHz should be less than 4 dB. If the 25 kHz loss exceeds 4 dB, then the lineup loss will be as listed in 5b and will require a WB repeater.

6. For those switches which have WECO 824/303 units on the wideband interswitch trunks or on long-distance wideband subscriber lines, all other subscribers on that switch must meet the lineup loss as listed in 5b to provide sufficient input level to the WECO units.

7. If the loss limits listed in item 5a cannot be met, wideband repeater(s) will be required and the lineup loss will be as listed in item 5b.

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TABLE 5. CROSS-REFERENCE BETWEEN DESCRIPTION OF DCS SERVICE ITEM NUMBER AND APPLICABLE CIRCUIT PARAMETER CODE

ITEM NUMBER	CIRCUIT PARAMETER CODE	ITEM NUMBER	CIRCUIT PARAMETER CODE
1A	V1	5C	D2
1B	S1	5D	D2
1C	Z1	5E	D2
1D	Z4(1)	5F	D2
1E	S1	5G	D2
1F	V1	5H	D2
1G	N1	5I	
1H	N2	5J	S1
1J	N3	5K	
1K	V1	5L	
1L	V1	5M	S1
1M	V1	5N	
1N	V1	5O	
1P	D2	5P	
1Q	D2	5Q	S1
1R	S1	6A	S1
1S	S1		
1T	S1	6C	S1
1U	S0	7A	
2A	D2	7B	S3
3A	V2	7C	Z2
3B	S3	7D	Z4(1)
3C	S3	7E	Z2
4A	V2	7F	S3
4B	S3	8A	Z3
4C	S1	8B	Z4(1)
4D	S2	8C	
4E	S3	8D	S3
4F	S3	8E	S3
4G	S3	8F	S1
5A	N2	9A	X1
5B	N3	9B	X2

(1)See enclosure 8 for Z4 parameters.

Enclosure 1

TM EXTRACTS

LESSON 3

TM 11-6625-2643-12 EXTRACT

EXTRACT

TM 11-6625-2643-12

Table 8-1. Controls, Jacks and Switches.

ITEM NUMBER	ITEM	FUNCTION
1	POWER SWITCH	Connects battery to the test set (Turns on power).
2	48 Volt Jack	Provision for connecting station battery to test set.
3	BATT TEST (push button)	Connects the meter to the battery test circuit which indicates the condition of the batteries.
4	HOLD (2 position switch)	When switch is ON, a hold coil is connected across the line jack and terminals.
5	MON (AC) Jack	Provision for connecting a telephone headset to monitor the tone being measured.
6	MON (DC) Jack	Provision for connecting an external DC monitoring (Recorder or Meter) device in series with the meter.
7	FILTER (Rotary Switch)	Selects the desired filter to be used when measuring the test signal.
8	SENS (1dB/Step)	It adjusts the amount of gain necessary in the set to obtain a meter reading. Greatest accuracy is obtained when the upper portion of the meter scale is used. The left switch is in steps of 1 dB. The right switch is in steps of 10 dB. The black numbers represent dBm. The blue numbers represent dBrn.
9	INPUT (Rotary Switch)	Selects the function of the input circuits.
10	LINE (Binding Posts)	Provisions for connecting circuit uner test by using GR (Bananna) type connector.
11	LINE (Jack)	Provision for connecting the circuit under test using a patch cord.
12	GND (Binding Post)	Provided to allow a ground connection to be made to the test set when the ground is not connected through the patch cord or GR type connector.
13	DIAL (Jack)	Provisions for connecting a dial circuit or subscriber set with a dial to LINE jack, when the INPUT switch is in the DIAL/TALK position.
14	METER	VU-DB scale calibrated in black divisions with numbers from +3 to -15 dB. Between +3 and -3 the scale is calibrated in 0.2 dB divisions. 0.5 dB divisions are used between -3 and -10 and 1 dB divisions are used between -10 and -15.

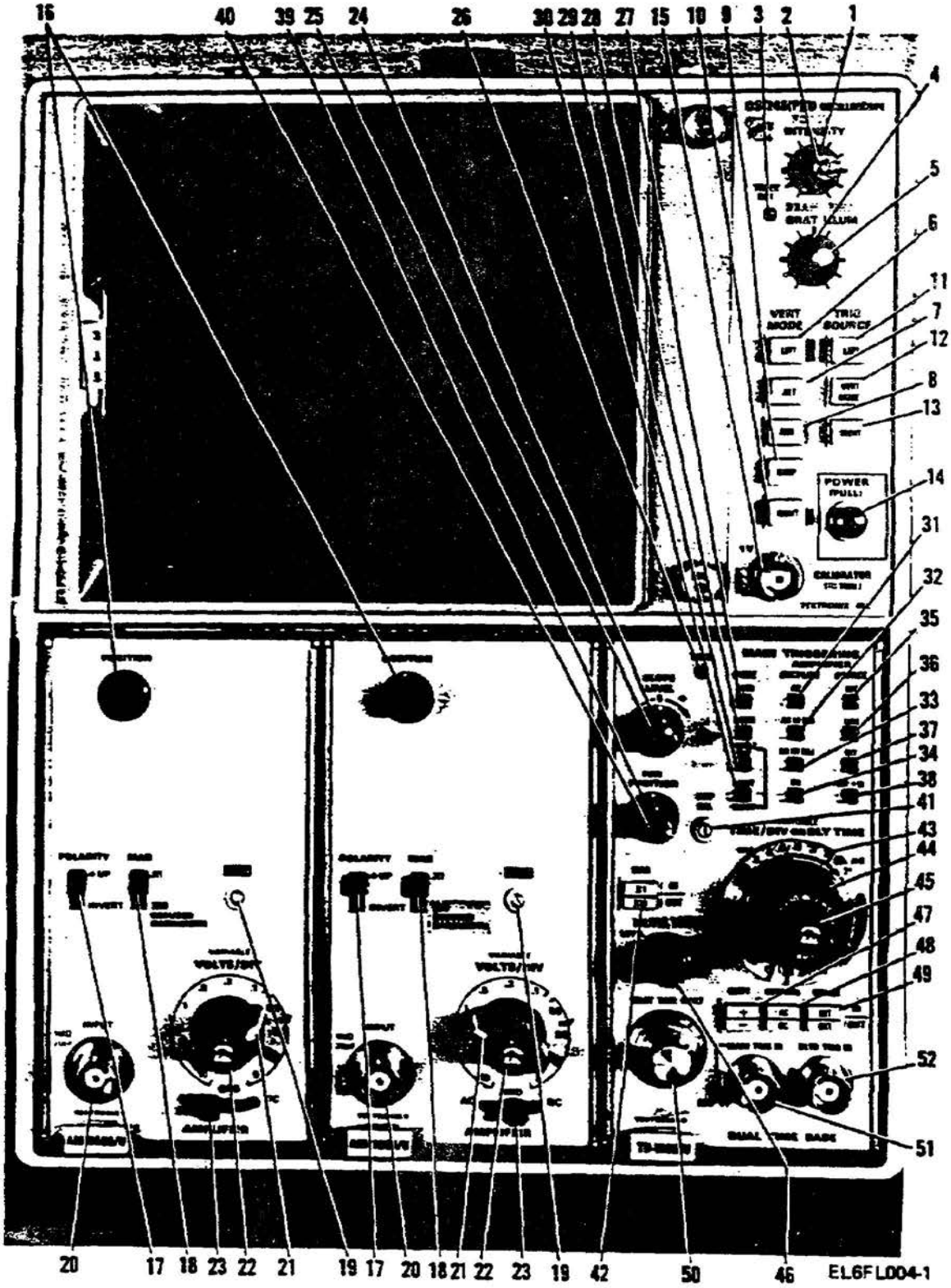
Table 8-1. Controls, Jacks and Switches (Continued).

ITEM NUMBER	ITEM	FUNCTION
14 (cont.)	METER	dBrn scale calibrated in black divisions and blue numbers from +13 to -5 dBrn. Between +13 and +7, the scale is calibrated in 0.2 dB divisions. 0.5 dB division are used between +7 and 0, and 1 dB divisions are used between 0 and -5. A VU quality scale is marked in three colors: GREEN between 0 and +3 dB YELLOW between -6 and 0 dB RED between -15 and -6 dB

TM EXTRACTS

LESSON 3

TM 11-6625-2658-14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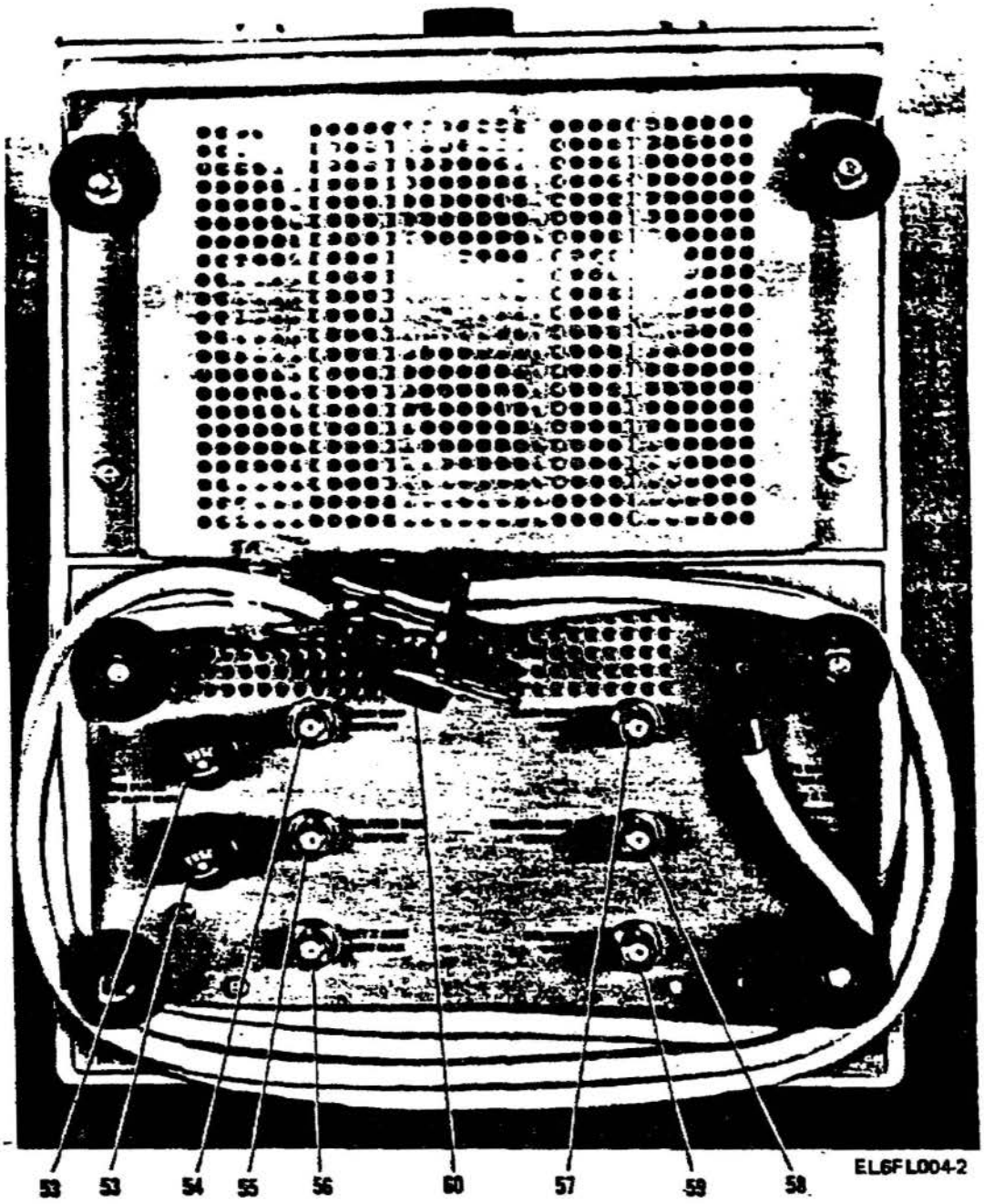

Figure 3-1. Oscilloscope controls, indicators, protective devices and connectors (sheet 2 of 2).

Table 3-1. Controls, Indicators, Protective Devices, and Connectors

Index number	Item	Reference designation	Function
		OSCILLOSCOPE FRONT PANEL	
1	INTENSITY Control.	A1R102	Controls brightness of display. Inoperative when horizontal plug-in compartment is empty.

Table 3-1. Controls, Indicators, Protective Devices, and Connectors—Continued

Index number	Item	Reference designation	Function
2	FOCUS potentiometer.	A1R1045	Controls definition of display.
3	TRACE ROT potentiometer.	A1R1025	Controls alignment of trace with horizontal graticule lines.
4	GRAT ILLUM potentiometer.	A1R1095	Controls brightness of graticule lines.
5	BEAM FIND switch.	A1S1030	Spring-loaded switch. When pressed, causes display to be compressed to within graticule area independent of control settings or applied signals.
	VERT MODE switches		
6	LEFT.	A1A4S1021A	Selects signal for display from left-hand vertical amplifier.
7	ALT.	A1A4S1021B	Selects signals for display from left-hand and right-hand vertical amplifiers in alternating pattern. Signals are switched after each sweep.
8	ADD.	A1A4S1021C	Selects signals for display from both vertical amplifiers. Signals are algebraically added and sum is displayed.
9	CHOP.	A1A4S1021D	Selects signals for display from left-hand and right-hand vertical amplifiers in alternating pattern. Signals are switched at a 1-megaHertz rate under control of internal oscillator.
10	RIGHT.	A1A4S1021E	Selects signal for display from right-hand vertical amplifier.
	TRIG SOURCE switches		
11	LEFT.	A1A4S1011A	Selects trigger signal from left-hand vertical amplifier.
12	VERT MODE.	A1A4S1011B	Trigger signal automatically follows vertical displays except when chopped vertical mode is selected. In chopped mode, trigger occurs at 1-megaHertz rate under control of internal oscillator.
13	RIGHT.	A1A4S1011C	Selects trigger signal from right-hand vertical amplifier.
14	POWER switch.	A1S1001	Push-pull switch. Controls power to oscilloscope.
15	CALIBRATOR connector.	J1086	Connects cable (BNC) to calibrator output signal.
	Vertical Amplifier Front Panel (for both vertical amplifiers)		
16	POSITION control.	A2R45 A4R45	Controls vertical position of trace.
17	POLARITY switch.	A2S32 A4S32	Provides display inversion. In +UP position, positive-going input signal causes upward trace deflection; in INVERT position, positive-going input signal causes downward trace deflection.
18	MAG switch.	A2S47B A4S47B	Provides decreasing deflection factor. In x1 position, deflection factor is as selected by VOLTS/DIV switch and VARIABLE potentiometer; in x10 REDUCED BANDWIDTH position, deflection factor is 1/10 that selected by VOLTS/DIV switch and VARIABLE potentiometer.
19	GAIN potentiometer.	A2A2R38 A4A2R38	Controls deflection factor fine calibration.
20	INPUT connector.	A2J10 A4J10	Connects amplifier input signal cable (BNC).
21	VOLTS/DIV switch.	A2A1A2S2 A4A1A2S2	Selects calibrated deflection factors from 5 millivolts per division to 10 volts per division in 11 steps in 1, 2, 5, . . . sequence.
22	VARIABLE potentiometer switch.	A2A2R239/S239 A4A2R239/S239	Provides continuously variable uncalibrated settings (up to 2.5 times) between calibrated deflection factor steps. Extends range to 25 volts per division or more.
23	AC/GND/DC switch.	A2A1A2S1 A4A1A2S1	Selects input coupling mode. In AC position, input signal is capacitively coupled to amplifier input with dc component blocked. In GND position, amplifier input is grounded, while maintaining same input signal load (provides charge path for ac coupling capacitor to precharge input circuit before switching input to ac). In DC position, all components of input signal are coupled to amplifier input.

EXTRACT

TM 11-6625-2658-12

Table 3-1. Controls, Indicators, Front-panel Devices, and Connectors—Continued

Index number	Item	Reference designation	Function
	Dual Time Base Front Panel		
24	LEVEL potentiometer.	A3R4	Determines amplitude point on trigger signal at which triggering occurs.
25	SLOPE switch.	A3S4	Selects either positive- or negative-going slope of trigger signal.
26	TRIG'D indicator.	A3DS8	Indicates that main sweep is triggered and will produce display with correct setting of position and intensity controls.
	MAIN TRIGGERING switches		
	MODE switches (provide selection of main triggering mode and indicate selection)		
27	AUTO.	A3A5S1	When pressed, sweep is initiated by applied trigger signal at point selected by LEVEL and SLOPE controls, if trigger signal repetition rate is above 30 Hertz and within range selected by COUPLING switch. Triggered sweep can be obtained only over amplitude range of applied trigger signal. When LEVEL control is set outside amplitude range, trigger repetition rate is below lower frequency limit (or above upper limit for AC HF REJ), or trigger signal is inadequate, sweep free runs at rate selected by TIME/DIV switch to provide reference trace.
28	NORM.	A3A5S2	When pressed, sweep is initiated by applied trigger signal at point selected by LEVEL and SLOPE controls over frequency range selected by COUPLING switch. Triggered sweep can be obtained only over amplitude range of applied trigger signal. If LEVEL control is set outside amplitude range, trigger repetition rate is outside the frequency range selected by COUPLING switch, or trigger signal is inadequate, no trace is displayed.
29	SINGLE SWP.	A3A5S3	When pressed, further sweeps cannot be displayed after one sweep until RESET switch is pressed. Display is triggered as in NORM operation using main triggering controls.
30	RESET-READY.	A3A5S4	When pressed while in single sweep mode, one sweep is displayed at next occurrence of trigger pulse (if triggering settings are correct). Indicator comes on and remains on until trigger is received, indicating that unit is reset. After trigger receipt and sweep display, indicator goes out.
	AMPLIFIER COUPLING switches (provide selection of main trigger coupling)		
31	AC.	A3A3S1	When pressed, dc components of signals are rejected and ac signals below approximately 30 Hertz are attenuated. AC signals between 30 Hertz and 50 megaHertz are accepted intact.
32	AC LF REJ.	A3A3S2	When pressed, dc components of signals are rejected and ac signals below approximately 30 kiloHertz are attenuated. AC signals between 30 kiloHertz and 50 megaHertz are accepted intact.
33	AC HF REJ.	A3A3S3	When pressed, dc components and signals below 30 Hertz and above 50 kiloHertz are attenuated. Signals within range of 30 Hertz to 50 kiloHertz are accepted intact.
34	DC.	A3A3S4	When pressed, all signals from dc to 50 megaHertz are accepted.
	AMPLIFIER SOURCE switches (provide selection of main trigger source and indicate selection)		
35	INT.	A3A2S1	When pressed, trigger signal is obtained from associated vertical amplifier.
36	LINE.	A3A2S2	When pressed, trigger signal is obtained from sample of oscilloscope input power frequency.

Table 3-1. Controls, Indicators, Protective Devices, and Connectors—Continued

Index number	Item	Reference designation	Function
37	EXT.	A3A2S3	When pressed, trigger signal is obtained from external source through MAIN TRIG IN connector (BNC).
38	EXT ÷ 10.	A3A2S4	Same as EXT, except that trigger signal is attenuated to approximately 10 percent of input amplitude.
39	POSITION potentiometer.	A3R8A	Provides coarse adjustment of horizontal position of trace.
40	FINE potentiometer.	A3R8B	Provides fine adjustment of horizontal position of trace.
41	SWP CAL potentiometer.	A3A1R290	Provides adjustment to match gain of dual time base to main frame for calibrated sweep rates.
42	MAG switch.	A3A6S762	Selects horizontal magnification. X1 (IN) selects unmagnified sweep at basic rate indicated by TIME/DIV switch setting. X10 (OUT) increases sweep rate of main and delayed sweep generator by horizontally expanding center centimeter of display 10 times.
43	*TIME/DIV OR DLY TIME switch.	A3A1A1S100A	Selects basic sweep rate of main sweep generator for operation in main sweep display mode, and selects delay time (to be multiplied by DELAY TIME MULT 10-turn dial potentiometer setting) for operation in intensified or delayed sweep display modes. MAG switch must be in X1 position (IN) and VARIABLE potentiometer/switch must be in CAL position for indicated sweep rate.
44	*Delayed time/division switch, intensify switch.	A3A1A1S100B, A3A1A1S252	Selects sweep rate of delayed sweep generator for operation in delayed sweep and intensified display modes. VARIABLE control must be in extreme clockwise (CAL) position and MAG switch must be in X1 position (IN) for indicated sweep rate.
45	VARIABLE potentiometer/switch.	A3A1R144/S144	Provides uncalibrated, continuously variable deflection factors between calibrated settings of TIME/DIV OR DLY TIME switch. Uncalibrated deflection factor range is extended to at least 12.5 seconds per division. When control is set to clockwise extreme, switch is operated to select calibrated deflection factors.
46	DLY'D TRIG potentiometer/switch.	A3R5/S5	Selects mode and level for delayed triggering. When control is turned to clockwise extreme (RUNS AFTER DLY TIME position), delayed sweep runs immediately following delay time selected by TIME/DIV OR DLY TIME switch and DELAY TIME MULT 10-turn dial potentiometer. Delayed SLOPE, COUPLING, and SOURCE switches are not activated. When control is turned counterclockwise from switch detent, delayed sweep is triggerable. LEVEL potentiometer then selects point on trigger signal at which delayed sweep is triggered. Delayed SLOPE, COUPLING, and SOURCE switches are activated.
47	SLOPE switch.	A3A7S40	Alternate-action switch. Selects portion of trigger signal to start delayed sweep. + (IN) position-delayed sweep is triggered from positive-going portion of trigger signal. − (OUT) position-delayed sweep is triggered from negative-going portion of trigger signal.
48	COUPLING switch.	A3A7S41	Alternate-action switch. Selects method of coupling trigger signal to delayed trigger circuits. AC (IN) position—dc signal components are rejected and ac signals below approximately 30 Hertz are attenuated; signals between 30 Hertz and 50 megaHertz are accepted intact. DC (OUT) position—all signals from dc to 50 megaHertz are accepted intact.
49	SOURCE switch.	A3A7S42	Alternate-action switch. Selects source of delayed trigger signal and determines function of DLY'D TRIG IN connector. INT (IN) position—delayed trigger

Table 3-1. Controls, Indicators, Protective Devices, and Connectors—Continued

Index number	Item	Reference designation	Function
			signal is obtained from associated vertical amplifier. EXT (OUT) position—delayed trigger signal is obtained from external source through DLY'D TRIG IN connector (BNC).
50	DELAY TIME MULT 10-turn dial potentiometer.	A3R9	Selects variable sweep delay between 0 and 10.0 times delay indicated by TIME/DIV or DLY TIME switch setting.
51	MAIN TRIG IN OR AMP IN connector.	A3J1	Connects cable (BNC) to dual time base for external triggering signal input. When MAIN TRIGGERING *AMPLIFIER SOURCE EXT or EXT ÷ 10 switch is* pressed and TIME/DIV OR DLY'D TIME switch is set to any other position than AMPL, external trigger input is connected to main triggering circuits. When MAIN TRIGGERING AMPLIFIER SOURCE EXT or EXT ÷ 10 switch is pressed and TIME/DIV OR DLY'D TIME switch is set to AMPL, external horizontal input is connected.
52	DLY'D TRIG IN connector.	A3J3	Connects cable (BNC) to dual time base for external delayed triggering signal input.
		OSCILLOSCOPE REAR PANEL	
53	LINE FUSES.	A1A6F1000 and A1A6F1001	Provide overload protection to oscilloscope circuits.
54	MAIN SWP OUTPUT connector.	A1A6J174	Connects cable (BNC) to monitor main sweep output signal.
55	DELAYED SWP OUTPUT connector.	A1A6J179	Connects cable (BNC) to monitor delayed sweep output signal.
56	EXT Z AXIS connector.	A1A6J1050	Connects cable (BNC) to supply external intensification control signal.
57	MAIN SWP GATE OUTPUT connector.	A1A6J187	Connects cable (BNC) to monitor main sweep gate output signal.
58	DELAYED SWP GATE OUTPUT connector.	A1A6J183	Connects cable (BNC) to monitor delayed sweep gate output signal.
59	DELAYED TRIG OUTPUT connector.	A1A6J192	Connects cable (BNC) to monitor delayed trigger output signal.
60	Power input connector and cable.	A1A6P1000	Connects line power to oscilloscope.

NOTE

The interrelationships between the TIME/DIV OR DLY switch, the delayed time/division switch, and the intensify switch are complex. For full and efficient use of these functions, the following definitions of the display modes must be understood:

Main Sweep—In main sweep mode, the time base switches are locked together and the time per division (sweep rate) is bracketed by the black lines on the TIME/DIV OR DLY TIME switch. Only the main time base (sweep) generator operates in this mode.

Intensified Sweep—In intensified sweep mode, both time base generators are used, but only the main sweep is displayed. The delayed sweep generator unblanking signal is used to intensify (brighten) the main sweep display when the delayed sweep generator runs. The main time-base sweep rate is bracketed by the black lines on the TIME/DIV OR DLY TIME switch. The delayed time base sweep rate is selected by pulling the delayed time/division switch out and turning it clockwise. With the switch pulled out, an intensified zone appears on the main sweep. The start of the intensified zone is determined by the DELAY TIME MULT dial setting. The duration of the intensified zone is determined by the delayed time/division switch setting. The purpose of the intensified sweep mode is to locate the portion of the trace that is to be displayed in delayed sweep mode.

Delayed Sweep—In delayed sweep mode, the delayed time/division switch is pushed in and the part of the display shown in the intensified zone discussed previously is then displayed on the delayed sweep and expanded over the full 10-centimeter horizontal scale. The magnitude of expansion from intensified to delayed mode is the ratio of main sweep to delayed sweep time per division settings. The delay time from the start of the main sweep to start of delayed sweep is found by multiplying the main sweep time per division by the DELAY TIME MULT dial setting. The delayed sweep mode enables the operator to select any part of the main sweep display and expand that part for more careful analysis and to make precise time difference measurements.

Section II. OPERATING PROCEDURES

3-2. General

This section provides the information necessary to operate the oscilloscope and includes operating instructions and procedures for operator's checks and adjustments. The oscilloscope features a combination of display functions for a wide range of signal measurement applications. The major functions consist of five main frame and four time base generator modes. These modes are defined as follows:

a. Main Frame Modes.

(1) *Left.* Selects signal applied to left vertical plug-in channel for crt display.

(2) *Alternate.* Selects signals alternately from left and right vertical plug-in channels for display on crt.

US ARMY SIGNAL SCHOOL

LESSON 1 ..... COMMUNICATION CIRCUIT QUALITY

PRACTICE EXERCISE/SOLUTION SHEET

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1. b--Learning event 1, page 1.
2. c--Learning event 2, paragraph 2a, page 2.
3. a--Learning event 2, paragraph 2b, page 2.
4. c--Learning event 3, paragraph a, page 2.
5. a--Learning event 4, paragraph b, (4), (b), page 7.
6. a--Learning event 5, paragraph b, page 8.
7. b--Learning event 6, paragraph c, page 9.
8. c--Learning event 6, paragraph a, page 9
9. d--Learning event 8, paragraph a, page 11.
10. c--Learning event 8, paragraph a, page 11.
11. b--Learning event 8, paragraph c, page 12.
12. b--Learning event 9, paragraph a, (3), page 13.
13. d--Learning event 9, paragraph c, page 14.
14. d--Learning event 9, paragraph c, (2), page 14.
15. c--Learning event 11, paragraph e, page 18.
16. d--Learning event 11, paragraph f, page 18.
17. c--Learning event 11, paragraph f, page 18.
18. a--Learning event 12, paragraph a, (3), page 19.
19. d--Learning event 12, paragraph b, (5), page 20.
20. a--Learning event 12, paragraph b, (7), page 20.

All concerned will be careful that neither this solution nor information concerning it comes into the possession of students, or prospective students, who have not completed the work to which it pertains.

US ARMY SIGNAL SCHOOL

LESSON 2..... CONCEPTS OF CIRCUIT CONDITIONING

PRACTICE EXERCISE/SOLUTION SHEET

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1. a--Learning event 1, page 28.

2. a--Learning event 2, paragraph a, page 29.

3. c--Learning event 2, paragraph a, page 30.

4. d--Learning event 3, paragraph h(3), page 33.

5. d--Learning event 3, paragraph d, page 31.

6. d--Learning event 3, paragraph b, page 31.

7. a--Learning event 4, page 33.

8. c--Learning event 5, page 33.

9. a--Learning event 5, paragraph i, page 37.

10. a--Lesson 2, 300-175-9 Extract, table 1, items 1a, 1k, 1l, 1m, 1n, page 74 and 75.

11. c--Lesson 2, 300-175-9 Extract, table 1, item 1j, page 75.

12. a--Lesson 2, 300-175-9 Extract, table 2, pages 80-83.

    NOTE: Compare the parameter characteristics of the parameter codes V1, V2, and D1.

13. a--Lesson 2, 300-175-9 Extract, item 8b, page 79.

    NOTE: Locate Z4 parameter code in table 5 and cross reference to the item number, then locate the item number, then locate the item number in table 1 for the description of service.

14. b--Lesson 2, 300-175-9 Extract, table 4, page 88.

15. b--Lesson 2, 300-175-9 Extract, table 2 , characteristic b, page 81.

16. d--Lesson 2, 300-175-9 Extract, table 4, page 88.

17. a--Learning event 5, paragraphs c and d, and lesson 2, DCAC 300-175-9 Extract, table 2, characteristic b., page 81.

Nonsecure voice transmission requires circuit parameter VI. The loss concerning frequency characteristic of code VI should not exceed the limits of 8 dB less loss (-) at 0.4 kHz or 20 dB more loss (+) at 2.8 kHz than the loss at 1,004 Hz. Loss has to be calculated from levels. Less loss is equivalent to a higher level, so 8 dB less loss at 0.4 kHz is equivalent to a level 8 dB above +2 dBm at 1,004 Hz, or +10 DBm. Conversely, more loss is equivalent to a lower level, so 20 dB more loss at 2.8 kHz is equivalent to a level 20 dB below +2 dBm at 1,000 Hz, or -18 dBm.

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18. b--Learning event 5, paragraph (d), page 38 and DCAC 300-175-9 Extract, table 2, page 80. (appendix).

The maximum net loss is the total loss between the output level of the sending terminal at 1.0 kHz as compared with the output level of the receive line amplifier. Table 2 gives the maximum net loss variation parameter for code VI as ±4 dB. Since the output level of the receive line amplifier is +2 -dBm, the sending level must lie between the limits of ± dB from that level, or +6 dBm to -2 dBm, calculated as follows:

(+2 dBm) +(4 dB) = +6 dBm (+2 dBm) -(4 dB) = 2 dBm

19. d--Learning event 5, paragraph (d), page 38 and DCAC 300-175-9 Extract, table 2, page 80.

Table 2, item h shows a maximum allowable channel noise to be 43 dBrnc0. This is 43 dB above the reference level of -90 dBm (O dBrn with C-message weighting). In terms of actual value of dBm, the noise level will be 43 dB above the level of -90 dBm, calculated as follows: -90 dBm +43 dB = -47 dBm. Note that although -47 dBm is a smaller figure than -90 dBm, it represents a higher level because it is closer to 0 dBm.

20. b--Lesson 2, DCAC 300-175-9 Extract, table 4, page 88 & e9.

All concerned will be careful that neither this solution nor information concerning it comes into the possession of students, or prospective students, who have not completed the work to which it pertains.

US ARMY SIGNAL SCHOOL

LESSON 3..... CONCEPTS OF CIRCUIT CONDITIONING

PRACTICE EXERCISE/SOLUTION SHEET

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1. b--Learning event 1, paragraph b, page 49..
2. d--Learning event 1, paragraph c, page 49.
3. c--Learning event 3, page 50.
4. c--Learning event 2, page 49.
5. a--Learning event 3, paragraph (f), page 589.
6. b--Learning event 5, 59.
7. d--Learning event 6, page 61.
8. d--Learning event 6, paragraph a, page 61.
9. a--Learning event 6, paragraph e, page 62.

0 dBm is equal to +90 dBrn. +5 dBm is therefore 5 dB above +90 dBrn, or +95 dBrn.

10. c--Learning event 7, paragraph b, page 64.
11. a--Learning event 8, paragraph a, page 66.
12. c--Lesson 3, TM 11-6625-2643-12 Extract, item 7, page 93.
13. b--Lesson 3, TM 11-6625-2643-12 Extract, item 14, page 93.
14.
15.

TM EXTRACT

LESSON 2

DCAC 300-175-9

TABLE 1. DCS TECHNICAL SCHEDULES FOR GOVERNMENT-OWNED CIRCUITS

ITEM NUMBER	DESCRIPTION OF DCS SERVICE
	Technical Schedules pertinent to services not mentioned herein will be developed on a case-by-case basis as requests for these services are received by the responsible DCA Circuit Allocation and Engineering Organization. When warranted by the degree of usage, an appropriate Technical Schedule for the particular service will be published by DCA.
	CATEGORY 1: USER-TO-USER CIRCUITS
	VOICE
1A	Nonsecure voice circuit.
1B	Secure voice, operating at 2400 baud.
1C	Secure voice, operating at 50,000 b/s. This is a special schedule pertaining to transmission over metallic facilities without regenerators.
1D	Secure voice, operating at 50,000 b/s. This is a special schedule pertaining to long-distance transmission over radio systems.
1E	Alternate voice/record, including secure S1 voice or data, operating at rates from 2400 b/s up to 9600 b/s. Circuit parameter code S3 is not available for user-to-user service but was developed to permit interconnection of up to five tandem S3 links and obtain S1 circuit performance on an end-to-end basis.
	FACSIMILE
IF	Facsimile transmission that can be accommodated over a voice grade channel with no special conditioning. If the required facsimile (including telephoto) service involves special conditioning of the channel, specific circuit parameters will be based on transmission means, circuit length, and characteristics of the equipment used to terminate the circuits.

Enclosure 1

TABLE 1. DCS TECHNICAL SCHEDULES FOR GOVERNMENT-OWNED CIRCUITS (CON.)

ITEM NUMBER	DESCRIPTION OF DCS SERVICE
	CATEGORY 1: USER-TO-USER CIRCUITS (CON.)
	TELEGRAPH AND DATA
1G	Less than 46 baud. Includes 60 wpm teletypewriter and other d.c. keying service.
1H	46 through 75 baud. Includes 75 wpm and 100 wpm teletypewriter and other d.c. keying service.
1J	76 through 150 baud. Includes 110 baud teletypewriter and other d.c. keying service.
1K	Less than 46 baud. Used where d.c. keying is converted to tone on a single channel basis.
1L	46 through 75 baud. Used where d.c. keying is converted to tone on a single channel basis.
1M	76 through 150 baud. Used where d.c. keying is converted to tone on a single channel basis.
1N	066-068 IBM transceivers (10 to 40 cpm).
1P	300 through 600 baud. Includes data card or other service.
1Q	1200 baud. Includes data card or other service.
1R	2400 b/s; alternate voice/record service.
1S	4800 b/s; alternate voice/record service.
1T	9600 and 7200 b/s; alternate voice record service.
1U	1200 to 16000 b/s when using data modems containing adaptive equalizers.

Enclosure 1

TABLE 1. DCS TECHNICAL SCHEDULES FOR GOVERNMENT-OWNED CIRCUITS (CON.)

ITEM NUMBER	DESCRIPTION OF DCS SERVICE
	CATEGORY 2: VOICE FREQUENCY CARRIER TELEGRAPH (VFCT) SYSTEMS
2A	VFCT
	CATEGORY 3: AUTOVON ACCESS LINES
3A	Voice grade.
3B	Special grade, alternate voice/record access from AUTODIN switch, and 2400 through 9600 b/s secure voice access from secure voice terminals, cordboard (SECORD), SEVAC, and other secure four-wire switchboards.
3C	Special grade, alternate voice/record.
	CATEGORY 4: AUTOVON TRUNKS
4A	Interswitch voice grade.
4B	Interswitch special grade, not transoceanic (no regenerators at either end).
4C	Interswitch special grade, not transoceanic (regenerators at both ends).
4D	Interswitch special grade, not transoceanic (regenerators at one end).
4E	Interswitch special grade, alternate voice/record.
4F	Loop-around, regenerative, Option 1. Regenerators located physically at the AUTOVON Switching Center.
4G	Loop-around, regenerative, Option 2. Regenerators located physically at a remote site on Government property.

TABLE 1. DCS TECHNICAL SCHEDULES FOR GOVERNMENT-OWNED CIRCUITS (CON.)

ITEM NUMBER	DESCRIPTION OF DCS SERVICE
	CATEGORY 5: AUTODIN ACCESS LINES
5A	75 baud; d.c. keying.
5B	150 baud; d.c. keying.
5C	75 baud; from terminal to switch or to a bridge at a transmission nodal point, tone keying.
5D	150 baud; from terminal to switch or to a bridge at a transmission nodal point, tone keying.
5E	300 baud; from terminal to switch or to a bridge at a transmission nodal point, tone keying.
5F	600 baud; from terminal to switch or to a bridge at a transmission nodal point, tone keying.
5G	1200 baud; limited to data service only.
5H	1200 b/s multiplexed; from a user or transmission nodal point where a VF channel is multiplexed or bridged with any compatible combination of 75-, 150-, 300-, or 600-baud modems not to exceed 1200 b/s total. VF bridging is used at transmission nodal points to serve noncollocated users.
5I	Not used.
5J	2400 b/s; alternate voice record service.
5K	Not used.
5L	Not used.
5M	4800 b/s; alternate voice/record service.
5N	Not used.

Enclosure 1

TABLE 1. DCS TECHNICAL SCHEDULES FOR GOVERNMENT-OWNED CIRCUITS (CON.)

ITEM NUMBER	DESCRIPTION OF DCS SERVICE
	CATEGORY 5: AUTODIN ACCESS LINES (CON.)
5O	Not used.
5P	Not used.
5Q	9600 and 7200 b/s; alternate voice record data service.
	CATEGORY 6: AUTODIN INTERSWITCH TRUNKS
6A	2400 b/s through 4800 b/s; dedicated circuit from one AUTODIN switch to another.
6B	Not used.
6C	9600 and 7200 b/s; alternate voice/record service.
	CATEGORY 7: AUTOSEVOCOM ACCESS LINES
7A	Not used.
7B	Secure voice terminal, 2400 b/s, to four-wire JOSS or AUTOVON switch.
7C	Secure voice terminal, 50 kb/s baseband, to SECORD or AUTOSEVOCOM switching facility without regenerators over metallic facilities.
7D	Secure voice terminal, 50 kb/s baseband, to special 758 switch or cordboard (SECORD) or AN/FTC-31 over long-distance carrier facilities.
7E	Secure voice terminal, 50 k/s baseband to AN/FTC-31, over metallic facilities.
7F	Secure voice terminal, operating at 9600 b/s to JOSS or AUTOVON switch.

TABLE 1. DCS TECHNICAL SCHEDULES FOR GOVERNMENT-OWNED CIRCUITS (CON.)

ITEM NUMBER	DESCRIPTION OF DCS SERVICE
	CATEGORY 8: AUTOSEVOCOM TRUNKS
8A	50 kb/s baseband, over metallic facilities without regenerators.
8B	50 Kb/s baseband, over long-distance carrier facilities.
8C	Not used.
8D	2400 b/s (JOSS to either a JOSS or a cordboard) (SECORD).
8E	2400 b/s (SEVAC to JOSS or 5-D switchboard).
8F	Interswitch trunk operating at 2400 or 9600 b/s providing secure voice service. (This service is derived from the AUTOVON.)
	CATEGORY 9: 60-108 kHz BASIC GROUPS
9A	Unconditioned Wideband Service. This item normally supports user-supplied FDM 60-108 kHz group level equipment.
9B	Conditioned Wideband Service. This item normally supports a 50 kb/s requirement through the DCS by use of special GFE modem and GFE auxiliary set, such as the WECO type 303 data modem and WECO type 842 data auxiliary set which provides interconnection of subscribers on a 4-kHz basis whenever the 50 kb/s signal is removed from the user's 4-wire line. The derived service is similar to item 7D. The AN/USC-26 group data modem also may be used in deriving this service, but in the half group mode of operation the data signal level (Circuit Parameter Code X2, item k, table 2) should be reduced to -8 dBm0.
	CATEGORY 10: DIGITAL SERVICES
	(See Enclosure 8.)

Enclosure 1

TABLE 2. DCS TECHNICAL SCHEDULES FOR GOVERNMENT-OWNED CIRCUITS (CIRCUIT PARAMETERS) (CON.)

CHARACTERISTICS	UNIT OF MEASURE	HP	S0	S1	S2	S3	V1	V2	D1	D2	N (1-3)
d. Maximum Change[3] In Audio Frequency	Hz		±5	±5	±5	±5	±5	±5	±5	±5	
e. Longitudinal Balance (Minimum)	dB		40	40	40	40	40	40	40	40	
f. Total Peak Telegraph Distortion (Maximum)	%										20
g. Bias Distortion (Maximum Mark or Space)	%										8
h. Idle Circuit[4] Noise (Maximum Allowable)	dBrnC0										
km mi											
0-81 (0-50)			31	31	31	31	31	31	31	31	
81-161 (50-100)			34	34	34	34	34	34	34	34	
161-644 (100-400)			37	37	37	37	37	37	37	37	
644-1609 (400-1000)			41	41	41	41	41	41	41	41	
1609-2414 (1000-1500)			43	43	43	43	43	43	43	43	
2414-4024 (1500-2500)			45	45	45	45	45	45	45	45	
4024-6438 (2500-4000)			47	47	47	47	47	47	47	47	
6438-12874 (4000-8000)			50	50	50	50	50	50	50	50	
12874-25748 (8000-16000)			53	53	53	53	53	53	53	53	
i. Single Tone Interference Below Circuit Noise In Each Mileage Category (Maximum)	dB		3	3	3	3	3	3	3	3	
j. Impulse Noise[5] (Reference Level 65 dBrnC0; Measure with Tone	Counts above reference level (maximum in 15) minutes		15	15	15	15			15	15	

[3]This measurement is not required on circuits traversing only PCM systems.
[4]Consider a satellite channel as equivalent to a 3219 kilometer (2000-mile) landline channel in determining circuit length.
[5]Reference level 60 dBrnC0 for circuits traversing PCM systems only. Measurement made with previously sampled PCM channel loaded with 2604 Hz + 5 dBm0 tone. Includes gain and phase hits lasting less than 4 milliseconds.

TABLE 2. DCS TECHNICAL SCHEDULES FOR GOVERNMENT-OWNED CIRCUITS (CIRCUIT PARAMETERS)

This table specifies circuit parameters which correspond to the various types of DCS VF services specified in table 1 except for parameters SO and MP. SO is an optional parameter that the circuit engineer may substitute in lieu of the normally specified parameter whenever the circuit is to be terminated with modems employing adaptive equalizers. SO is normally obtained without special equalization equipment being introduced into the circuit. MP is also an optional parameter that the circuit engineer may substitute in lieu of the normally specified parameter whenever the circuit is to be terminated with modems employing multilevel modulation techniques that require above-average signal-to-noise and linearity characteristics. Provision of the MP parameters normally requires special routing of the circuit over "hand selected" transmission channels.

CHARACTERISTICS	UNIT OF MEASURE	MP	SO	S1	S2	S3	V1	V2	D1	D2	M (1-3
a. Frequency Response[1]	dB										
KHz											
0.3-2.7										-2 to +6	
0.3-3.0			-3 to +12	-2 to +6	-1.5 to +4.5	-1 to +3		-3 to +8	-2 to +6	-3 to +12	
0.4-2.8							-8 to +20				
0.5-2.5			-2 to +8								
0.5-2.8				-1 to +3	-0.5 to +2	-0.5 to +1.5			-1 to +3		
0.6-2.4							-7 to +12				
1.0-2.4										-1 to +3	
0.7-2.3								-1 to +3			
b. Maximum Envelope[2] Delay Variation Allowable in Each Specified Band	micro-second										
KHz											
0.5-2.8				3000	1500	600			3000		
0.6-2.6				1500	750	300			1500		
0.8-2.6			1750							1750	
1.0-2.4										1000	
1.0-2.6				500	250	100			500		
c. Maximum Net Loss Variation (with respect to time)	dB		±4	±4	±3	±2	±4	±2	±4	±4	

[1]Loss frequency characteristics are given in terms of comparison to the measured loss at 1004 Hz. For example, in the S1 schedule, the loss frequency characteristic should not exceed the range of 2 dB less loss (-) to 6 dB more loss (+) between 0.3-3.0 KHz when compared to the measured loss at 1004 Hz. This frequency is used to avoid subharmonics of the 8 KHz frequency used extensively in PCM/TDM systems. Caution: Circuits equipped with CY-104 ( ) PCM equipment may not meet the above parameters without external equalization.

[2]Caution: Circuits equipped with CY-104 ( ) PCM equipment may not meet this parameter without external equalization.

TABLE 2. DCS TECHNICAL SCHEDULES FOR GOVERNMENT-OWNED CIRCUITS (CIRCUIT PARAMETERS) (CON.)

CHARACTERISTICS	UNIT OF MEASURE	HP	S0	S1	S2	S3	V1	V2	D1	D2	M (1-3)
k. Terminal Impedance (600 ohms)	% Tolerance		±10	±10	±10	±10	±10	±10	±10	±10	
l. Data Transmission Level (Composite)	dBm0		-13	-13	-13	-13	-13	-13	-13	-13	
m. Phase Jitter[6] (Maximum Peak-to-Peak)	Degrees		10	10	10	10			10	10	
n. Harmonic[7] Distortion	dBm0		-40	-40	-40	-40	-40	-40	-40	-40	
o. Gain Hits[8] (>4 msec) Gain Change >3 dB or >4 dB	Counts (Maximum) in 15 minutes		8 6	8 6	8 6	8 6			8 6	8 6	
p. Phase Hits[9] (>20 degrees and >4 msec.	Counts (Maximum in 15 minutes exceeding threshold)		8	8	8	8			8	8	
q. Dropouts (>12 dB and >10 msec)	Dropouts (Maximum in 15 minutes)		2	2	2	2			2	2	

[6]Not required for circuits traversing PCM systems only.

[7]This parameter is obsolete and has been replaced by parameter s. A 704 Hz test tone at -10 dBm0 is used.

[8]Gain hits are sudden changes in the gain or loss of a circuit. Measurement made at circuit activation and as necessary as a troubleshooting aid.

[9]Phase hits are sudden changes in phase of the transmitted signal caused by the transmission path. Measurement made at circuit activation and as a troubleshooting aid.

TABLE 2. DCS TECHNICAL SCHEDULES FOR GOVERNMENT-OWNED CIRCUITS
(CIRCUIT PARAMETERS) (CON.)

CHARACTERISTICS	UNIT OF MEASURE	HP	SO	S1	S2	S3	V1	V2	D1	D2	N (1-3)
r. Signal to[10] C-Notched Noise Ratio	dB	28	24	24	24	24	24	24	24	24	
s. Nonlinear Distortion (Using 4-tone method)[11]											
(1) Signal to Second Order Distortion	dB	35	25	25	25	25	25	25	25	25	
(2) Signal to Third Order Distortion	dB	40	30	30	30	30	30	30	30	30	

The Technical Schedule portion of this table concludes with characteristic s, above. The characteristics following are provided as a troubleshooting aid and may be used on an optional basis. They are intended to assist the technician in clearing troubles on circuits traversing PCM systems, which are not revealed by the characteristics specified above. Characteristic w will be experienced mainly on PCM equipments which employ a single coder-decoder for all channels. Loading of channels as specified for characteristic w may involve channels not accessible to the end point circuit tester. Characteristic x is useful in identifying high-level transient signals on circuits which elude measurements made with conventional level measuring equipment and thus also may be useful in measuring signals that traverse FDM systems.

t. Gain Linearity at Input Levels of: dBm0	dB										
0 to -37			±0.5	±0.5	±0.5	±0.5	±0.5	±0.5	±0.5	±0.5	±0.5
-37 to -50			±1.0	±1.0	±1.0	±1.0	±1.0	±1.0	±1.0	±1.0	±1.0
-50 to -54			±3.0	±3.0	±3.0	±3.0	±3.0	±3.0	±3.0	±3.0	±3.0

[10]Measurement is made with 1004 Hz -10 dBm0 holding tone. Both idle circuit noise and C-notched noise are to be measured on all circuits except as noted otherwise. Optional measurement on circuits traversing noncompandored FDM facilities. Required measurement on circuits traversing compandored facilities, such as all-PCM systems and analog compandored FDM systems (e.g. type N carrier).

[11]Nonlinear distortion measured using the four-tone test method is the standard method of measurement of distortion in the DCS. The obsolete harmonic distortion parameter has been retained in this table for use by those stations not yet equipped with transmission impairment measurement sets.

TABLE 2. DCS TECHNICAL SCHEDULES FOR GOVERNMENT-OWNED CIRCUITS (CIRCUIT PARAMETERS) (CON.)

CHARACTERISTICS	UNIT OF MEASURE	HP	SO	S1	S2	S3	V1	V2	D1	D2	N (1-3)
u. Signal to Quantizing Distortion at Input Levels of: dBmO	dB										
0 to -30			33	33	33	33	33	33	33	33	
-30 to -40			27	27	27	27	27	27	27	27	
-40 to -45			22	22	22	22	22	22	22	22	
v. Circuit[12] Continuity (Dropouts >10 dB and >250 msecs)	Dropouts (Maximum in 24 hrs)		10	10	10	10	10	10	10	10	
w. Cross-Modulation[13] (from adjacent circuits) Maximum Notched Impulse Noise Threshold	dBrnO		57	57	57	57	57	57	57	57	
x. Maximum[14] Operating Signal Level (Peak) Reference Threshold 95 dBrnO Flat wtg	Counts above reference threshold (Maximum in 15 minutes)		15	15	15	15	15	15	15	15	

[12]This measurement may be made on circuits where loss of synchronization of the high bit rate digital trunk is suspected. Statistics are normally measured using a 1004 Hz -10 dBmO tone on the circuit and a strip chart recorder to record the dropouts.

[13]This measurement may be made on circuits wherever cross-modulation is suspected. Measurement made with previously scanned channel and measured circuit activated with 1004 Hz tone at a level of -10 dBmo.

[14]This measurement is made with an impulse noise measuring set bridged across the circuit during periods of maximum signal activity. The measurement indicates the presence of high-level transient signals which cause intermodulation distortion, cross-talk and cross-modulation of adjacent channels. It is noted that 95 dBrnO equates to a level of +5 dBmO.

TABLE 3. DCS TECHNICAL SCHEDULES FOR GOVERNMENT-OWNED CIRCUITS
GROUP BANDWIDTH CIRCUITS - FDM OR DATA DERIVED

CHARACTERISTICS	UNIT OF MEAS	X1	X2
a. Frequency Response kHz loss with respect to 104.08 kHz	dB		
km mi			
0-100 (0-62.5)		-1.3 to +1.8	-1.3 to +1.8
100-201 (62.5-125)		-2.0 to +2.9	-2.0 to +2.9
201-402 (125-250)		-2.5 to +4.0	-2.5 to +4.0
402-804 (250-500)		-2.9 to +4.0	-2.9 to +4.0
804-1609 (500-1000)		-3.3 to +4.9	-3.3 to +4.9
1609-3218 (1000-2000)		-4.4 to +4.9	-4.4 to +5.9
3218-6436 (2000-4000)		-4.4 to +6.7	-4.4 to +6.7
b. Envelope Delay (reference 84 kHz)			
(1) Equalized parabolic curve 64-104 kHz	micro-second		
km mi			
0-100 (0-62.5)			(See footnote (1))
100-201 (62.5-125)			
201-402 (125-250)			
402-804 (250-500)			
804-1609 (500-1000)			
1609-3218 (1000-2000)			
3218-6436 (2000-4000)			
(2) Unequalized, typical points on curve.			
Measured at 60 kHz		3000	
Measured at 64 kHz		300	
Measured at 108 kHz		2800	

(1) Use values for AN/USC-26 from figure 1.

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TABLE 3. DCS TECHNICAL SCHEDULES FOR GOVERNMENT-OWNED CIRCUITS GROUP BANDWIDTH CIRCUITS - FDM OR DATA DERIVED (CON.)

CHARACTERISTICS	UNIT OF MEAS	X1	X2
c. Amplitude Stability	dB		
Short Term (30 seconds)		±.5	±.5
Long Term (30 seconds)		±1.0	±1.0
d. Maximum Frequency Offset	Hz	±2	±2
e. Impedance	ohm		
(1) Balanced (preferred)		135	135
(2) Unbalanced		75	75
f. Return Loss, minimum over frequency range 60-108 kHz	dB	25	25
g. Interface Transmission Level Point (assuming Government-furnished interconnect filters)	dBm		
Group Channel Input Level		-34.5	-5 to -42
Group Channel Output Level		-12.0	-5 to -42
h. Phase Jitter, Peak-to-Peak	degree	10	10

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TABLE 3. DCS TECHNICAL SCHEDULES FOR GOVERNMENT-OWNED CIRCUITS GROUP BANDWIDTH CIRCUITS - FDM OR DATA DERIVED (CON.)

CHARACTERISTICS	UNIT OF MEAS	X1	X2
i. Random Noise Unweighted km / mi 0-804 (0-500) 804-1609 (500-1000) 1609-3218 (1000-2000) 3218-6436 (2000-4000	dBm0	 -38 -35 -32 -29	 -38 -35 -32 -29
j. Impulse Noise, Flat Weighting 15-Minute Measurement at -10 dBm0.	Maximum Count	175	175
k. Average (30-second) Long-Term Power in 60-108 kHz band, maximum permissible.	dBm0	-5	-5(2)
l. Maximum Operating Signal Power permitted in any 4-kHz subchannel. Total number of active channels must be such that characteristic k is not violated.	dBm0	-13	-13
m. Maximum Test Tone Power Level in any 4-kHz subchannel. Test duration less. than 5 minutes Test duration more than 5 minutes.	dBm0	 -10 -15	 -10 -15

(2)For half-group operation of the AN/USC-26, -8 dBm0 applies.

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TABLE 4. DCS TECHNICAL SCHEDULES FOR GOVERNMENT-OWNED CIRCUITS
Z1, Z2, Z3 TECHNICAL SCHEDULES

(Z1 through Z3 technical schedules establish the parameters for full-duplex 50 kbps transmission media within the bandwidth of 0.1 to 50 kHz terminated in a nominal 135 ohms. The Z Schedules apply only to terminals operating in the baseband mode.

Z1 Parameters are for a local circuit used to interconnect two KY-3 terminals over physical metallic nonloaded cable pairs. The lineup loss must portray a curve with a smooth rolloff.

Z2 Parameters are for a local circuit used to interconnect a KY-3 to a switchboard over metallic facilities as in Z1. However, since the switchboard provides no equalization, all equalization on the cable pair transmitting toward the switchboard must be "equipped by the line." Note the different requirements in each direction.

Z3 Parameters are for a trunk circuit used between two switchboards where no equalization capability exists at either end. It applies also to any wireline segment of a wideband long haul trunk.)

CHARACTERISTIC	UNIT OF MEASURE	Z1 BOTH DIRECTIONS	Z2 SUB TO SWITCH	Z2 SWITCH TO SUB	Z3 BOTH DIRECTIONS
1. Low-Frequency Noise[1,2]	dBm	-36	-36	-36	-36
2. S+N/N	dB	20	24	24	24
3. Impulse Noise[3] a. Wideband	1 count per second with threshold set at stated level (dB) below the received signal level.	12	12	12	12
b. AN/FTC-31 low frequency receive	1 count per second with threshold set at stated level (dB) below 2600 Hz SF level.		6		6

See page 89 for footnotes.

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TABLE 4. DCS TECHNICAL SCHEDULES FOR GOVERNMENT-OWNED CIRCUITS
Z1, Z2, Z3 TECHNICAL SCHEDULES (CON.)

CHARACTERISTIC	UNIT OF MEASURE	Z1 BOTH DIRECTIONS	Z2 SUB TO SWITCH	Z2 SWITCH TO SUB	Z3 BOTH DIRECTIONS
4. Net Loss Variation[2,4]	dB	±2	±2	±2	±2
5. Lineup Loss (kHz)	dB loss of 0dBm transmitted tone		(5)		
a. 0.1		+13	4	+13	
1.0		+12	4	+12	
3.0		+14	4	+14	
5.5		+17	4	+17	
10.0		+20	4	+20	
18.0		+23	4	+23	
25.0		+25	4	+25	
32.0		+27		+27	
50.0		+30	6	+30	
			(5&6)	(7)	
b. .1 to 50.0			-2, +2	-2, +2	-2, +2
1.0 to 40.0			-1, +1	-1, +1	-1, +1
6. Envelope Delay	Microsec reference @ 6 kHz	See figure 2	See figure 2	See figure 2	See figure 2
7. Nominal Data Input Signal Level	volts peak-to-peak	1	1	1	1

See page 17 for footnotes.

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Footnotes to table 4:

1. In no case should absolute power level exceed -36 dBm in the VF bandwidth.

2. Reference frequency is 1 kHz at 0 dBm0.

3. The impulse noise (IPN) meter is normally configured for dBrn. After measuring the received digitized voice signal with a dB meter, use the following equation for the dBrn setting:

dBrn = 90 + signal level (measured reading) - 12 dB

Example: If the signal level is measured to be -2 dBm, then dBrn = 90 - 2 - 12 = 76 dBrn. Set reference level dBrn dials as follows:

10 dB step dial at 60.
High-level dial at 16. (60 + 16 = 76 dBrn)
Mid-level dial at 10. (60 + 10 = 70 dBrn)
Low-level dial at 4. (60 + 4 = 64 dBrn)
Use 10.2 to 51 kHz (or external wideband) filter.

4. At the time of the alinement of the wideband repeaters in the subscriber to switch direction, adjust the receive level of the 1 kHz reference frequency to 0 dBm with the entire frequency response within the stated specifications (-1 to +1 dB between 1 and 40 kHz and -2 to +2 dB between .1 to 50 kHz.) In a later check, the reference 1 kHz receive level may vary (net loss variation) up to -2 or +2 dB from the 0 dB alinement level. The entire frequency curve should be equally displaced. For example, if the 1 kHz tone is 1 dB cold (or reading -1 dB on the meter indicating a +1 dB loss), then the entire frequency response curve must now be referred to the +1 dB loss level. The frequency response curve must fall within the shifted limits of 0 to +2 dB between 1 and 40 KHz and -1 to +3 dB between .1 to 50 kHz. If the 1 KHz tone is 2 dB hot, then the frequency response curve must fall within the limits of -3 and -1 dB between 1 and 40 kHz and -4 to 0 dB between .1 and 50 kHz.

5. A 4 dB loss at 25 kHz is maximum allowable loss. Loss from 0.1 to 18.0 kHz should be less than 4 dB. If the 25 kHz loss exceeds 4 dB, then the lineup loss will be as listed in 5b and will require a WB repeater.

6. For those switches which have WECO 824/303 units on the wideband interswitch trunks or on long-distance wideband subscriber lines, all other subscribers on that switch must meet the lineup loss as listed in 5b to provide sufficient input level to the WECO units.

7. If the loss limits listed in item 5a cannot be met, wideband repeater(s) will be required and the lineup loss will be as listed in item 5b.

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EXTRACT

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TABLE 5. CROSS-REFERENCE BETWEEN DESCRIPTION OF DCS SERVICE ITEM NUMBER AND APPLICABLE CIRCUIT PARAMETER CODE

ITEM NUMBER	CIRCUIT PARAMETER CODE	ITEM NUMBER	CIRCUIT PARAMETER CODE
1A	V1	5C	D2
1B	S1	5D	D2
1C	Z1	5E	D2
1D	Z4(1)	5F	D2
1E	S1	5G	D2
1F	V1	5H	D2
1G	N1	5I	
1H	N2	5J	S1
1J	N3	5K	
1K	V1	5L	
1L	V1	5M	S1
1M	V1	5N	
1N	V1	5O	
1P	D2	5P	
1Q	D2	5Q	S1
1R	S1	6A	S1
1S	S1		
1T	S1	6C	S1
1U	S0	7A	
2A	D2	7B	S3
3A	V2	7C	Z2
3B	S3	7D	Z4(1)
3C	S3	7E	Z2
4A	V2	7F	S3
4B	S3	8A	Z3
4C	S1	8B	Z4(1)
4D	S2	8C	
4E	S3	8D	S3
4F	S3	8E	S3
4G	S3	8F	S1
5A	N2	9A	X1
5B	N3	9B	X2

(1)See enclosure 8 for Z4 parameters.

Enclosure 1

TM EXTRACTS

LESSON 3

TM 11-6625-2643-12 EXTRACT

EXTRACT

TM 11-6625-2643-12

Table 8-1. Controls, Jacks and Switches.

ITEM NUMBER	ITEM	FUNCTION
1	POWER SWITCH	Connects battery to the test set (Turns on power).
2	48 Volt Jack	Provision for connecting station battery to test set.
3	BATT TEST (push button)	Connects the meter to the battery test circuit which indicates the condition of the batteries.
4	HOLD (2 position switch)	When switch is ON, a hold coil is connected across the line jack and terminals.
5	MON (AC) Jack	Provision for connecting a telephone headset to monitor the tone being measured.
6	MON (DC) Jack	Provision for connecting an external DC monitoring (Recorder or Meter) device in series with the meter.
7	FILTER (Rotary Switch)	Selects the desired filter to be used when measuring the test signal.
8	SENS (1dB/Step)	It adjusts the amount of gain necessary in the set to obtain a meter reading. Greatest accuracy is obtained when the upper portion of the meter scale is used. The left switch is in steps of 1 dB. The right switch is in steps of 10 dB. The black numbers represent dBm. The blue numbers represent dBrn.
9	INPUT (Rotary Switch)	Selects the function of the input circuits.
10	LINE (Binding Posts)	Provisions for connecting circuit uner test by using GR (Bananna) type connector.
11	LINE (Jack)	Provision for connecting the circuit under test using a patch cord.
12	GND (Binding Post)	Provided to allow a ground connection to be made to the test set when the ground is not connected through the patch cord or GR type connector.
13	DIAL (Jack)	Provisions for connecting a dial circuit or subscriber set with a dial to LINE jack, when the INPUT switch is in the DIAL/TALK position.
14	METER	VU-DB scale calibrated in black divisions with numbers from +3 to -15 dB. Between +3 and -3 the scale is calibrated in 0.2 dB divisions. 0.5 dB divisions are used between -3 and -10 and 1 dB divisions are used between -10 and -15.

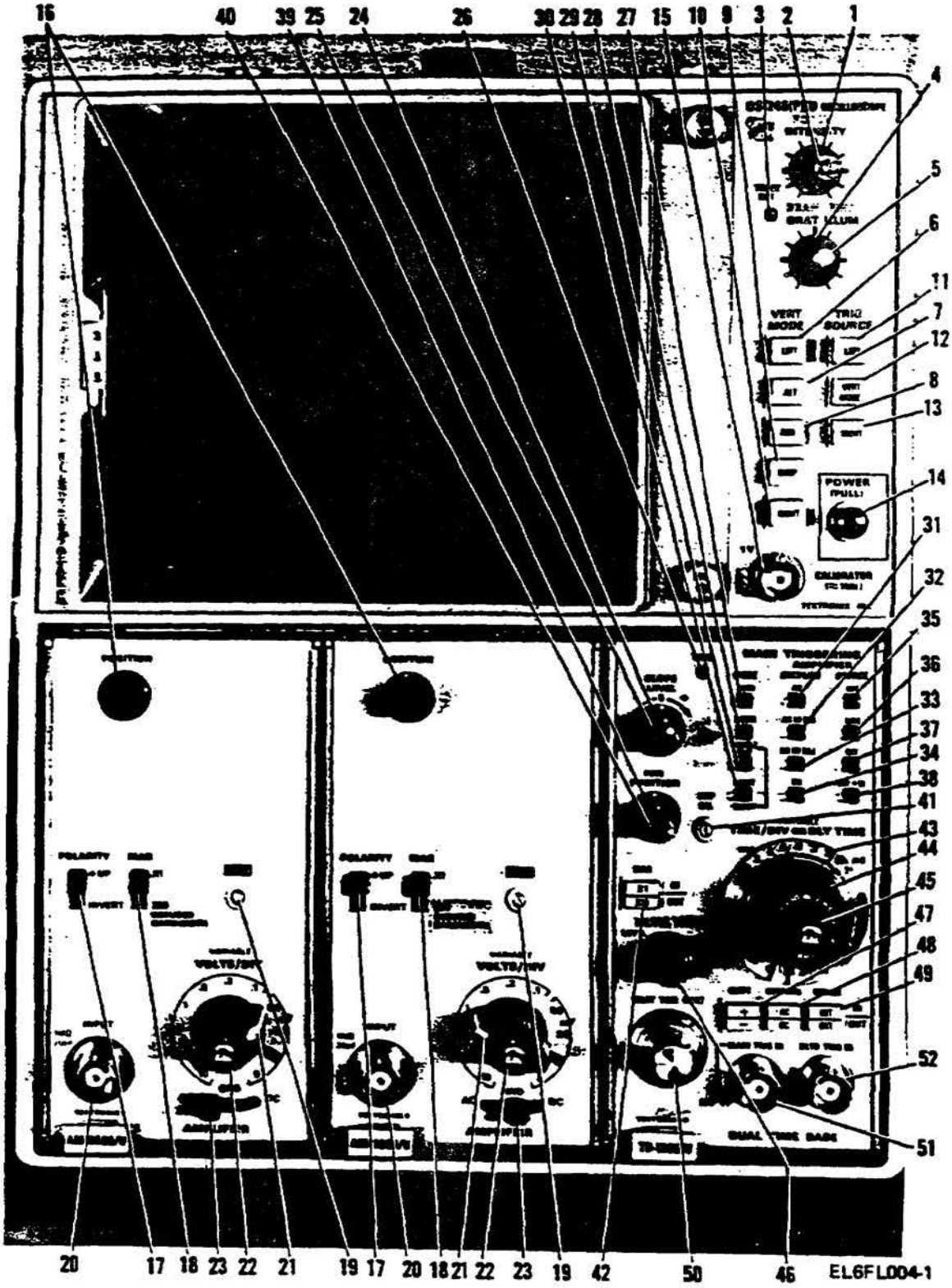
Table 8-1. Controls, Jacks and Switches (Continued).

ITEM NUMBER	ITEM	FUNCTION
14 (cont.)	METER	dBrn scale calibrated in black divisions and blue numbers from +13 to -5 dBrn. Between +13 and +7, the scale is calibrated in 0.2 dB divisions. 0.5 dB division are used between +7 and 0, and 1 dB divisions are used between 0 and -5. A VU quality scale is marked in three colors: GREEN between 0 and +3 dB YELLOW between -6 and 0 dB RED between -15 and -6 dB

TM EXTRACTS

LESSON 3

TM 11-6625-2658-14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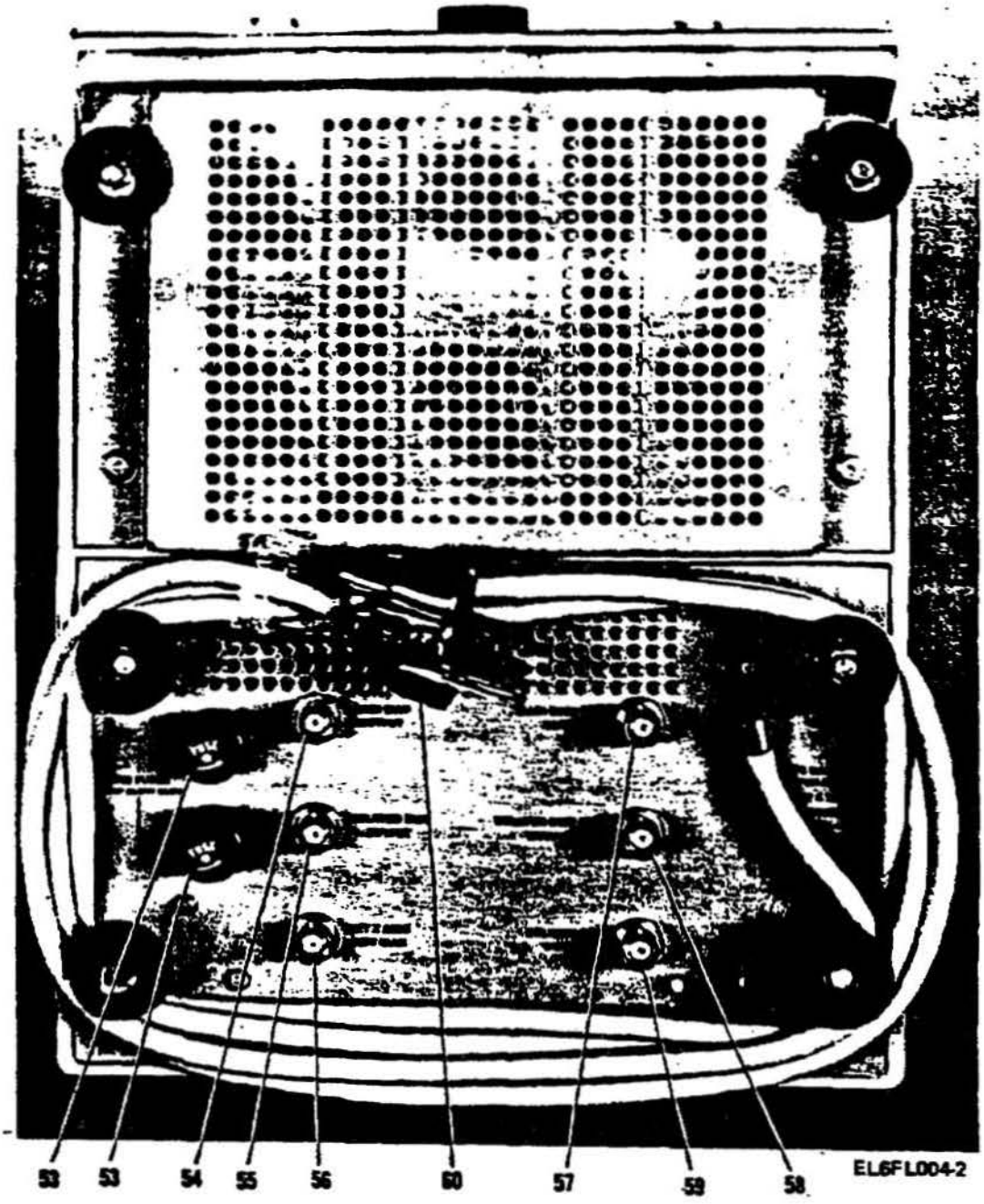

Figure 3-1. Oscilloscope controls, indicators, protective devices and connectors (sheet 2 of 2).

Table 3-1. Controls, Indicators, Protective Devices, and Connectors

Index number	Item	Reference designation	Function
		OSCILLOSCOPE FRONT PANEL	
1	INTENSITY Control.	A1R102	Controls brightness of display. Inoperative when horizontal plug-in compartment is empty.

Table 3-1. Controls, Indicators, Protective Devices, and Connectors—Continued

Index number	Item	Reference designation	Function
2	FOCUS potentiometer.	A1R1045	Controls definition of display.
3	TRACE ROT potentiometer.	A1R1025	Controls alignment of trace with horizontal graticule lines.
4	GRAT ILLUM potentiometer.	A1R1095	Controls brightness of graticule lines.
5	BEAM FIND switch.	A1S1030	Spring-loaded switch. When pressed, causes display to be compressed to within graticule area independent of control settings or applied signals.
	VERT MODE switches		
6	LEFT.	A1A4S1021A	Selects signal for display from left-hand vertical amplifier.
7	ALT.	A1A4S1021B	Selects signals for display from left-hand and right-hand vertical amplifiers in alternating pattern. Signals are switched after each sweep.
8	ADD.	A1A4S1021C	Selects signals for display from both vertical amplifiers. Signals are algebraically added and sum is displayed.
9	CHOP.	A1A4S1021D	Selects signals for display from left-hand and right-hand vertical amplifiers in alternating pattern. Signals are switched at a 1-megaHertz rate under control of internal oscillator.
10	RIGHT.	A1A4S1021E	Selects signal for display from right-hand vertical amplifier.
	TRIG SOURCE switches		
11	LEFT.	A1A4S1011A	Selects trigger signal from left-hand vertical amplifier.
12	VERT MODE.	A1A4S1011B	Trigger signal automatically follows vertical displays except when chopped vertical mode is selected. In chopped mode, trigger occurs at 1-megaHertz rate under control of internal oscillator.
13	RIGHT.	A1A4S1011C	Selects trigger signal from right-hand vertical amplifier.
14	POWER switch.	A1S1001	Push-pull switch. Controls power to oscilloscope.
15	CALIBRATOR connector.	J1086	Connects cable (BNC) to calibrator output signal.
	Vertical Amplifier Front Panel (for both vertical amplifiers)		
16	POSITION control.	A2R45 A4R45	Controls vertical position of trace.
17	POLARITY switch.	A2S32 A4S32	Provides display inversion. In +UP position, positive-going input signal causes upward trace deflection; in INVERT position, positive-going input signal causes downward trace deflection.
18	MAG switch.	A2S47B A4S47B	Provides decreasing deflection factor. In x1 position, deflection factor is as selected by VOLTS/DIV switch and VARIABLE potentiometer; in x10 REDUCED BANDWIDTH position, deflection factor is $^1/_{10}$ that selected by VOLTS/DIV switch and VARIABLE potentiometer.
19	GAIN potentiometer.	A2A2R38 A4A2R38	Controls deflection factor fine calibration.
20	INPUT connector.	A2J10 A4J10	Connects amplifier input signal cable (BNC).
21	VOLTS/DIV switch.	A2A1A2S2 A4A1A2S2	Selects calibrated deflection factors from 5 millivolts per division to 10 volts per division in 11 steps in 1, 2, 5, ... sequence.
22	VARIABLE potentiometer switch.	A2A2R239/S239 A4A2R239/S239	Provides continuously variable uncalibrated settings (up to 2.5 times) between calibrated deflection factor steps. Extends range to 25 volts per division or more.
23	AC/GND/DC switch.	A2A1A2S1 A4A1A2S1	Selects input coupling mode. In AC position, input signal is capacitively coupled to amplifier input with dc component blocked. In GND position, amplifier input is grounded, while maintaining same input signal load (provides charge path for ac coupling capacitor to precharge input circuit before switching input to ac). In DC position, all components of input signal are coupled to amplifier input.

Table 3-1. Controls, Indicators, Processor Devices, and Connectors—Continued

Index number	Item	Reference designation	Function
	Dual Time Base Front Panel		
24	LEVEL potentiometer.	A3R4	Determines amplitude point on trigger signal at which triggering occurs.
25	SLOPE switch.	A3S4	Selects either positive- or negative-going slope of trigger signal.
26	TRIG'D indicator.	A3DS8	Indicates that main sweep is triggered and will produce display with correct setting of position and intensity controls.
	MAIN TRIGGERING switches		
	MODE switches (provide selection of main triggering mode and indicate selection)		
27	AUTO.	A3A5S1	When pressed, sweep is initiated by applied trigger signal at point selected by LEVEL and SLOPE controls, if trigger signal repetition rate is above 30 Hertz and within range selected by COUPLING switch. Triggered sweep can be obtained only over amplitude range of applied trigger signal. When LEVEL control is set outside amplitude range, trigger repetition rate is below lower frequency limit (or above upper limit for AC HF REJ), or trigger signal is inadequate, sweep free runs at rate selected by TIME/DIV switch to provide reference trace.
28	NORM.	A3A5S2	When pressed, sweep is initiated by applied trigger signal at point selected by LEVEL and SLOPE controls over frequency range selected by COUPLING switch. Triggered sweep can be obtained only over amplitude range of applied trigger signal. If LEVEL control is set outside amplitude range, trigger repetition rate is outside the frequency range selected by COUPLING switch, or trigger signal is inadequate, no trace is displayed.
29	SINGLE SWP.	A3A5S3	When pressed, further sweeps cannot be displayed after one sweep until RESET switch is pressed. Display is triggered as in NORM operation using main triggering controls.
30	RESET-READY.	A3A5S4	When pressed while in single sweep mode, one sweep is displayed at next occurrence of trigger pulse (if triggering settings are correct). Indicator comes on and remains on until trigger is received, indicating that unit is reset. After trigger receipt and sweep display, indicator goes out.
	AMPLIFIER COUPLING switches (provide selection of main trigger coupling)		
31	AC.	A3A3S1	When pressed, dc components of signals are rejected and ac signals below approximately 30 Hertz are attenuated. AC signals between 30 Hertz and 50 megaHertz are accepted intact.
32	AC LF REJ.	A3A3S2	When pressed, dc components of signals are rejected and ac signals below approximately 30 kiloHertz are attenuated. AC signals between 30 kiloHertz and 50 megaHertz are accepted intact.
33	AC HF REJ.	A3A3S3	When pressed, dc components and signals below 30 Hertz and above 50 kiloHertz are attenuated. Signals within range of 30 Hertz to 50 kiloHertz are accepted intact.
34	DC.	A3A3S4	When pressed, all signals from dc to 50 megaHertz are accepted.
	AMPLIFIER SOURCE switches (provide selection of main trigger source and indicate selection)		
35	INT.	A3A2S1	When pressed, trigger signal is obtained from associated vertical amplifier.
36	LINE.	A3A2S2	When pressed, trigger signal is obtained from sample of oscilloscope input power frequency.

Table 3-1. Controls, Indicators, Protective Devices, and Connectors—Continued

Index number	Item	Reference designation	Function
37	EXT.	A3A2S3	When pressed, trigger signal is obtained from external source through MAIN TRIG IN connector (BNC).
38	EXT ÷ 10.	A3A2S4	Same as EXT, except that trigger signal is attenuated to approximately 10 percent of input amplitude.
39	POSITION potentiometer.	A3R8A	Provides coarse adjustment of horizontal position of trace.
40	FINE potentiometer.	A3R8B	Provides fine adjustment of horizontal position of trace.
41	SWP CAL potentiometer.	A3A1R290	Provides adjustment to match gain of dual time base to main frame for calibrated sweep rates.
42	MAG switch.	A3A6S762	Selects horizontal magnification. X1 (IN) selects unmagnified sweep at basic rate indicated by TIME/DIV switch setting; X10 (OUT) increases sweep rate of main and delayed sweep generator by horizontally expanding center centimeter of display 10 times.
43	*TIME/DIV OR DLY TIME switch.	A3A1A1S100A	Selects basic sweep rate of main sweep generator for operation in main sweep display mode, and selects delay time (to be multiplied by DELAY TIME MULT 10-turn dial potentiometer setting) for operation in intensified or delayed sweep display modes. MAG switch must be in X1 position (IN) and VARIABLE potentiometer/switch must be in CAL position for indicated sweep rate.
44	*Delayed time/division switch, intensify switch.	A3A1A1S100B, A3A1A1S252	Selects sweep rate of delayed sweep generator for operation in delayed sweep and intensified display modes. VARIABLE control must be in extreme clockwise (CAL) position and MAG switch must be in X1 position (IN) for indicated sweep rate.
45	VARIABLE potentiometer/switch.	A3A1R144/S144	Provides uncalibrated, continuously variable deflection factors between calibrated settings of TIME/DIV OR DLY TIME switch. Uncalibrated deflection factor range is extended to at least 12.5 seconds per division. When control is set to clockwise extreme, switch is operated to select calibrated deflection factors.
46	DLY'D TRIG potentiometer/switch.	A3R5/S5	Selects mode and level for delayed triggering. When control is turned to clockwise extreme (RUNS AFTER DLY TIME position), delayed sweep runs immediately following delay time selected by TIME/DIV OR DLY TIME switch and DELAY TIME MULT 10-turn dial potentiometer. Delayed SLOPE, COUPLING, and SOURCE switches are not activated. When control is turned counterclockwise from switch detent, delayed sweep is triggerable. LEVEL potentiometer then selects point on trigger signal at which delayed sweep is triggered. Delayed SLOPE, COUPLING, and SOURCE switches are activated.
47	SLOPE switch.	A3A7S40	Alternate-action switch. Selects portion of trigger signal to start delayed sweep. +(IN) position-delayed sweep is triggered from positive-going portion of trigger signal. −(OUT) position-delayed sweep is triggered from negative-going portion of trigger signal.
48	COUPLING switch.	A3A7S41	Alternate-action switch. Selects method of coupling trigger signal to delayed trigger circuits. AC (IN) position—dc signal components are rejected and ac signals below approximately 30 Hertz are attenuated; signals between 30 Hertz and 50 megaHertz are accepted intact. DC (OUT) position—all signals from dc to 50 megaHertz are accepted intact.
49	SOURCE switch.	A3A7S42	Alternate-action switch. Selects source of delayed trigger signal and determines function of DLY'D TRIG IN connector. INT (IN) position—delayed trigger

Table 3-1. Controls, Indicators, Protective Devices, and Connectors—Continued

Index number	Item	Reference designation	Function
			signal is obtained from associated vertical amplifier. EXT (OUT) position—delayed trigger signal is obtained from external source through DLY'D TRIG IN connector (BNC).
50	DELAY TIME MULT 10-turn dial potentiometer.	A3R9	Selects variable sweep delay between 0 and 10.0 times delay indicated by TIME/DIV or DLY TIME switch setting.
51	MAIN TRIG IN OR AMP IN connector.	A3J1	Connects cable (BNC) to dual time base for external triggering signal input. When MAIN TRIGGERING *AMPLIFIER SOURCE EXT or EXT ÷ 10 switch is* pressed and TIME/DIV OR DLY'D TIME switch is set to any other position than AMPL, external trigger input is connected to main triggering circuits. When MAIN TRIGGERING AMPLIFIER SOURCE EXT or EXT ÷ 10 switch is pressed and TIME/DIV OR DLY'D TIME switch is set to AMPL, external horizontal input is connected.
52	DLY'D TRIG IN connector.	A3J3	Connects cable (BNC) to dual time base for external delayed triggering signal input.
		OSCILLOSCOPE REAR PANEL	
53	LINE FUSES.	A1A6F1000 and A1A6F1001	Provide overload protection to oscilloscope circuits.
54	MAIN SWP OUTPUT connector.	A1A6J174	Connects cable (BNC) to monitor main sweep output signal.
55	DELAYED SWP OUTPUT connector.	A1A6J179	Connects cable (BNC) to monitor delayed sweep output signal.
56	EXT Z AXIS connector.	A1A6J1050	Connects cable (BNC) to supply external intensification control signal.
57	MAIN SWP GATE OUTPUT connector.	A1A6J187	Connects cable (BNC) to monitor main sweep gate output signal.
58	DELAYED SWP GATE OUTPUT connector.	A1A6J183	Connects cable (BNC) to monitor delayed sweep gate output signal.
59	DELAYED TRIG OUTPUT connector.	A1A6J192	Connects cable (BNC) to monitor delayed trigger output signal.
60	Power input connector and cable.	A1A6P1000	Connects line power to oscilloscope.

NOTE

The interrelationships between the TIME/DIV OR DLY switch, the delayed time/division switch, and the intensify switch are complex. For full and efficient use of these functions, the following definitions of the display modes must be understood:

Main Sweep—In main sweep mode, the time base switches are locked together and the time per division (sweep rate) is bracketed by the black lines on the TIME/DIV OR DLY TIME switch. Only the main time base (sweep) generator operates in this mode.

Intensified Sweep—In intensified sweep mode, both time base generators are used, but only the main sweep is displayed. The delayed sweep generator unblanking signal is used to intensify (brighten) the main sweep display when the delayed sweep generator runs. The main time-base sweep rate is bracketed by the black lines on the TIME/DIV OR DLY TIME switch. The delayed time base sweep rate is selected by pulling the delayed time/division switch out and turning it clockwise. With the switch pulled out, an intensified zone appears on the main sweep. The start of the intensified zone is determined by the DELAY TIME MULT dial setting. The duration of the intensified zone is determined by the delayed time/division switch setting. The purpose of the intensified sweep mode is to locate the portion of the trace that is to be displayed in delayed sweep mode.

Delayed Sweep—In delayed sweep mode, the delayed time/division switch is pushed in and the part of the display shown in the intensified zone discussed previously is then displayed on the delayed sweep and expanded over the full 10-centimeter horizontal scale. The magnitude of expansion from intensified to delayed mode is the ratio of main sweep to delayed sweep time per division settings. The delay time from the start of the main sweep to start of delayed sweep is found by multiplying the main sweep time per division by the DELAY TIME MULT dial setting. The delayed sweep mode enables the operator to select any part of the main sweep display and expand that part for more careful analysis and to make precise time difference measurements.

Section II. OPERATING PROCEDURES

3-2. General

This section provides the information necessary to operate the oscilloscope and includes operating instructions and procedures for operator's checks and adjustments. The oscilloscope features a combination of display functions for a wide range of signal measurement applications. The major functions consist of five main frame and four time base generator modes. These modes are defined as follows:

a. Main Frame Modes.

(1) *Left.* Selects signal applied to left vertical plug-in channel for crt display.

(2) *Alternate.* Selects signals alternately from left and right vertical plug-in channels for display on crt.